THE BULLETIN

OF THE

AMERICAN CERAMIC SOCIETY

Volume 14 DECEMBER, 1935 Number 12

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Editorial and Advertising Offices: 2525 N. High St., Columbus, Ohio.
Publication Office: 20th & Northampton Sts., Easton, Pa.
Executive Office: 2525 N. High St., Columbus, Ohio.
Committee on Publications: L. Navias, *Chairman;* L. J. Trostel, M. F. Beecher, R. M. King, Ross C. Purdy

Entered as second-class matter at the post office at Easton, Pa., under the act of March 3, 1879.
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A Monthly Publication Devoted to Proceedings of the Society and Promotion of Coöperative Research of Technical, Scientific, and Art Questions

Volume 14 December, 1935 Number 12

PAPERS

REFRACTORY PROBLEMS IN BASIC ALLOY STEEL PRODUCTION*

By Gilbert Soler

Abstract

The various purposes for which refractories are used in a modern alloy steel plant are outlined, and the relation between steel quality and refractories costs is developed, coördinating the refractories problems with service conditions which arise in steel plants.

The viewpoint of the operator on the refractories problems connected with open-hearth and electric furnaces, ladles and accessories, soaking pits, reheating furnaces, and heat-treating furnaces is presented. The causes of refractories failures are discussed, together with methods for testing refractories.

I. Introduction

It is difficult for a steel producer to explain his individual problems to a refractories manufacturer. The operating and bricklayer superintendents have figures on service life of various refractories and, on this basis alone, they make selections for each specific use. They are hesitant in making a change.

Because better quality steel at lower cost will be made when refractories are especially adapted, several steel mills now employ men familiar with refractory qualities and production as well as with the problems of steel production. They have laboratories and conduct experimental work under operating conditions.

Alloy steel producers are concerned more with the quality of their steel as affected by refractories than they are with refractory service life and cost per ton. Steel consumers have developed rigid nonmetallic inclusion specifications. Refractory inclusions, originating from the furnace, spout, ladle, or mold will cause low cutter life and high tooling cost, and lines of weakness or stress and will result in poor surface finish.

Repairs during a furnace campaign are expensive and production delays are costly. Replacement or rebuilding should be required only at the end of a furnace campaign. Furnace design, fuel, combustion, and mechanical deterioration must be adjusted in keeping with the quality of the refractories.

Expensive refractories may, in some instances, prove most economical, while in others those of lower quality materials may be advantageously used. No one material is suitable for all applications, and the closer the producer of refractories works with the steel maker, the less trouble both will encounter.

II. Testing

With data on the physical and chemical properties of his product, the producer of refractories is in position to recommend the brand best suited for a given purpose.

The steel producer, of course, will make such standard tests as are necessary to determine which refractories are best for each of the several

* Presented at the 1935 Summer Meeting, Refractories Division, American Ceramic Society, State College, Pa., September 20, 1935. Received September 28, 1935.

purposes and check these determinations by actual service tests.

The refractories laboratory of the Timken Steel & Tube Company makes the following routine tests: pyrometric cone equivalent, simulative spalling, modified slag, deformation under load at high temperatures, permanent shrinkage in reheat, relative conductivity, bulk, apparent, and true specific gravity, crushing strength, transverse strength (dry and fired), drying, firing, and total shrinkage, apparent porosity, water of plasticity, screen, chemical analysis, and petrographic analysis.

Special tests are devised to obtain data not secured in the routine tests. These will differ in different plants.

It is usually best to make preliminary service tests on a small scale, followed by a large-scale test. Complete records should be kept of all service tests. Photographs should be made of the installation before the test, at intervals during the test, and at failure or at the end of the furnace campaign. Conditions during the test should be carefully noted and allowances made for unusual conditions. Samples taken from service tests should be studied to determine what actually caused the failure or why the material was successful.

The petrographic microscope can be used to good advantage in studying slag-attack failures, changes in structure due to time and temperature, and deterioration by gases and vapors. A thin section of slagged interface will show the structural relations between the slag and the refractory, and powder sections can be used to identify the various constituents present. Results can be readily interpreted by the phase diagrams of the various oxide systems. By means of the X-ray diffraction apparatus, the extent of solid-solution phases can be determined and opaque constituents identified.

III. Open-Hearth Furnaces

The length of an open-hearth furnace campaign is determined by the type of steel being made, the kind of fuel used, combustion conditions, furnace design, and the refractories. Cost of refractories per ton of steel produced at different plants can not be compared unless production conditions are alike. Refractories cost is only a fraction of the total cost and is affected by the other factors, being increased when the furnace is operated under positive hearth pressure. This increase, however, is offset by a large saving in fuel costs.

Maximum flame temperature at which an open-hearth furnace can be operated is limited by the temperature at which roof brick will fail. The present temperature limits could be raised and substantial savings made in melting time, thus increasing the production rate of the furnaces, if a refractory were available that would withstand these higher temperatures.

Silica brick are particularly suitable for use in roof and side-wall construction since they retain their load-carrying capacity to within 100°F of their fusion point. This property is attributed to the interlocking crystalline structure of the brick and to the fact that no large quantities of a eutectic liquid phase are formed at operating temperatures.

Although acid chemically, silica brick resist basic slag conditions because of the formation of immiscible liquids with ferrous, calcium, manganese, and magnesium oxides. Sodium and potassium oxides and alumina hinder immiscibility and should therefore be avoided in the manufacture of silica refractories and in the slags used with such refractories. To avoid spalling, silica refractories must be heated and cooled slowly through the inversion ranges of quartz, cristobalite, and tridymite. New silica brick contain approximately 35% of quartz, with the remainder of cristobalite and tridymite. In service, however, quartz changes into cristobalite and tridymite, giving a more stable structure. This makes silica brick more resistant to spalling after the first few heats. Usually a slight glazing occurs on the hot inner face of the brick, which tends to produce a monolithic structure.

When at a red heat (1200°F) or above, silica brick show good resistance to temperature shocks resulting from the addition of cold scrap to the furnace. Insulation of the furnace aids in maturing silica brick, the change of the quartz content occurring to a greater depth in the brick and thus giving them a higher resistance to spalling. In addition, their resistance to mechanical abrasion is good and for that reason silica brick are commonly used in the jambs and arches of charging doors.

Several courses of chrome brick are usually used to separate the magnesite brick in the bottom side walls from the silica brick used above. The chrome brick are thermochemically neutral both

to silica and magnesium oxide. This layer should be of sufficient depth to prevent molten silica from running down on the magnesite banks, as silica will flux magnesium oxide and cause difficulty.

Open-hearth furnace bottoms are usually made of a mixture of magnesite with approximately 20% of open-hearth slag as a bond. This mixture is fired in place on the bottom in $^1/_4$- to $^1/_2$-inch layers to a total depth of approximately $2^1/_2$ feet. Petrographic analysis shows the mineralogical constituents of such a bottom to be periclase, α- or β-dicalcium silicate, and possibly an olivine phase, oxides of magnesium, iron, and manganese in solid solution, and usually some dicalcium ferrite.

During service, such a bottom will change in composition. The ferric oxide combined as dicalcium ferrite, which provided a fusible bond when the bottom was made, may be reduced in service to ferrous oxide, which is taken into solution by the periclase along with iron oxide from the slag and bath in contact with the bottom. The new autogenous or solid-solution bond thus developed holds the periclase grains together in a tight and highly refractory mass. This bottom is slightly plastic, and any cracks which form as it cools readily heal during the next heat. The resistance of the bottom to abrasion from charged scrap is also improved by this slight plasticity.

Holes eroded in the bottom or banks by the action of the metal or slag should be patched after every heat with dead-burned or clinkered dolomite. In the case of bottoms which are kept in continuous service, clinkered dolomite with a sintered flux to prevent disintegration caused by hydration of uncombined lime may be used for the original bottom. Ground chrome ore is ordinarily used for hot-patching the furnace hearth in contact with silica brickwork and for building up ports, etc.

Magnesia is in thermochemical equilibrium with most open-hearth melt-down slags, which consist mineralogically of an olivine phase ($CaO:RO:SiO_2$). The RO content can be filled by CaO, FeO, MnO, or MgO, but CaO has the greatest affinity of these four oxides and MgO the least. Thus, if the 2:1 ratio is satisfied by calcium, ferrous, and manganese oxides, magnesium oxide will not be combined with the silica of the olivine phase.

As lime is added to the slag or works up through the bath from the bottom, the other oxides will be displaced by the formation of dicalcium silicate which will be in equilibrium with magnesium oxide. Thus it will be noted that the magnesium-oxide content of an open-hearth slag does not increase materially.

Ports, end walls, and end-wall bulkheads are subject to flame impingement and to the fluxing action of calcium and iron oxide carried over the bath by the flame. Silica, chrome, and magnesite refractories are used in these locations. Uptakes and downtakes are usually built of silica brick. Slag pockets and fantails are built of either silica or fireclay brick. Fireclay brick laid up in a high-temperature cement produce a tighter joint in fantail arches, thus reducing air infiltration.

Checker chambers are ordinarily built of silica or fireclay brick, with fireclay checker blocks. Silica, magnesite, and chrome refractories have been tried as checker blocks, but have not been as satisfactory as the fireclay blocks. Deterioration of checkers is primarily due to slagging caused by flue dusts composed mainly of iron oxide.

Inasmuch as checkers function as heat exchangers, the blocks should be selected for that property as well as for their refractory qualities. The loading is also heavy and, consequently, first-grade fireclay refractories are usually used for the purpose.

Tapholes in open-hearth furnaces are usually made of a mixture of burnt and raw dolomite. This mixture must be proportioned in such a manner as to produce a dense structure that will withstand the weight and action of the metal. At the same time, this mix must be soft enough to be easily knocked out with a tapping bar.

IV. Electric Furnaces

With certain exceptions, electric-arc furnaces require the same refractories as are used in open-hearth furnaces. The differences in melting are taken into consideration in the fundamental design of the furnaces, and the refractories must be selected accordingly. Intense local heating in the path of the electric arc occurs in electric furnaces.

The electric furnace bottoms are made of "burnt-in" magnesite or "tamped-in" periclase to which a synthetic bonding agent has been added. Standard practice calls for patching after every heat, clinkered dolomite being used as in the case of the open-hearth furnace. As the

oxidizing slag is similar to that used in open-hearth practice, magnesium oxide remains in thermochemical equilibrium with the slag as discussed under open-hearth technique.

The use of a second, or reducing, slag after the oxidizing slag has been removed from an electric furnace adds another difficulty to the problem of refractory selection. This slag is "made up" from lime, silica, and fluorspar, to which some coke is added. Petrographic analysis shows the presence of γ-dicalcium silicate and tricalcium silicate, and it is known that calcium carbide is also present. These constituents are in thermochemical equilibrium with the magnesium oxide as is the case in the open-hearth furnaces.

Reducing slags of this type are peculiar in that they disintegrate or "dust." This is caused by the β-to-γ transformation of dicalcium silicate at 1247°F, which is accompanied by an increase in volume of about 10%. It is prevented in open-hearth slags by the stabilization of the α- or β-dicalcium silicate by the large percentage of phosphorus pentoxide and ferric oxide present in the slag.

One difficulty found with electric-furnace bottoms is that of the reducing slag seeping into the cracks which develop as the bottom cools. On cooling below 1247°F, at which the β-to-γ transformation of dicalcium silicate takes place, there is a decided expansion with a consequent rupturing of the bottom.

Bottom side walls in electric furnaces are usually built of magnesite brick and the upper side walls of either magnesite or silica brick. Chromite refractories are seldom used since they may be reduced and the steel bath contaminated by the chrome. A thin layer of chromite cement, however, can be used between the magnesite and silica brick without danger of excessive contamination. Magnesite brick are generally used above the taphole in the area touched by the reducing slag when the furnace is tilted for tapping. Silica brick are suitable for use in the door jambs and arches which are subject to considerable mechanical abrasion.

Electric-furnace roofs, which are dome-shaped in form, are preconstructed of silica brick and placed in position by a crane. Usually two roofs are required for each furnace lining. This means that the second roof must be placed on a hot furnace and, consequently, preheating is desirable. Greatest wear occurs around the holes through which the electrodes pass due to the abrasive action of the flux-laden gases from the bath and to spalling. In some instances, high-grade fireclay brick have been used in electric-furnace roofs and have occasionally shown a life equivalent to that of silica brick.

V. Runners

Open-hearth furnace runners are usually made of plastic fire clay or of loam having a fairly low fusion point. Better steel, however, can be secured by using a higher grade of refractory material with less shrinkage and a higher fusion point. While such material may cost a little more, there is less chance of the stream of metal picking up nonmetallic inclusions which will detract from the quality of the finished steel. Ladle brick or special tile, bonded with high-temperature cement or fire clay, are used in electric-furnace runners as the runner must tip with the furnace.

Ladles are usually lined with low-porosity fireclay brick. These brick are laid up with thin, tight joints, either in high-temperature cement or fire clay. Some brands of ladle brick contain free silica and, although their fusion point is only about cone 23 (2840°F), they are fairly resistant to attack either by slag or steel. Some investigators attribute this to the free silica which sweats out of the brick and forms a smooth siliceous coating. This surface offers less area for attack.

Deterioration of ladle linings now commonly used is primarily due to the action of the slag used as an insulating blanket over the steel in the ladle, although the composition, viscosity, and temperature of the steel also have an effect, low-carbon and high-manganese steels being particularly destructive. In addition, the size and shape of the ladle, together with the direction and velocity of the stream during tapping, definitely affect ladle life. The period during which steel is held in the ladle during teeming offers possibilities for the solution and entrainment of refractory particles in the steel, and considerable study remains to be done in overcoming this danger.

Fireclay brick are theoretically unsuitable for ladle lining, but as yet no truly satisfactory brick has been developed. A basic material with the proper physical properties should be ideal, but such a product is not yet on the market. It is significant to note that although steel is made on basic bottoms and under a basic slag, inclusions

of magnesium oxide or calcium oxide are not found in the steel. These basic substances are not soluble in steel and are apparently not wetted by it. Likewise, they are resistant to the action of basic slags and fluxes. Chrome and magnesite brick have been tried in ladles but have been found unsatisfactory because of spalling, high heat conductivity, or chrome contamination of the steel. A distinct need exists for a good basic ladle brick in plants producing high-quality steel.

VI. Sleeves, Nozzles, and Stoppers

Sleeve brick are made of fire clay. They should be concentric and properly fired; otherwise cracking may occur which will allow the molten steel to reach and melt the stopper rod. High-temperature cement or fire clay may be used to lay up sleeve brick.

Nozzles should likewise be concentric, true to shape, and properly fired. Wells are usually constructed of a mixture of grog and fire clay tamped into shape and dried. The shape and contour of the nozzle-well determines the ease of seating the nozzle and the amount of swirling of the metal in the bottom of the ladle, making proper design and care in construction particularly important.

A graphite stopper head is ordinarily used. This material is sufficiently refractory and forms a tight seal with the nozzle, which is slightly plastic at teeming temperatures. These heads must be properly fired and contain no lamination cracks or lines of weakness. In selecting stoppers, care should be exercised to make sure that the composition, porosity, and texture is such that maximum resistance to erosion and failure is combined with low heat diffusion, to avoid possible failure of the inner steel rod or stopper pin when a heat has been only partially teemed.

All of these refractory ladle accessories are important in view of the fact that poor quality may cause nonmetallic inclusions in the finished steel or, in the case of failure, cause the loss of an expensive heat. Quality material should always be selected for these parts.

VII. Hot Tops

Hot tops are particularly important mold accessories whenever quality steel is being produced. They are usually made of fireclay, and they should be true to size, have a sufficiently high fusion point, and not spall or crack easily. Hot tops which are off-size may cause junction leaks during teeming, resulting in wasted metal and poor quality steel. Spalled pieces may cause nonmetallic inclusions.

If hot tops are not dry, or contain gas-forming materials, porosity in the ingot or other troubles may result. The fusion point should be cone 28 (2948°F) or higher to prevent sticking during stripping, for refractory material fused to the surface of the ingot will cause defects in the product during subsequent rolling operations. Cast-iron hot tops with an inner refractory lining of insulating brick protected by a slurry are also in use.

The thermal efficiency of a hot top in preventing pipe depends upon the relation existing between the size and shape of the hot top and the mold and upon the degree of heat conductivity, diffusivity, and capacity of the material used.

VIII. Mold Plugs

Mold plugs are usually made of fire clay and should be true to size so that they will fit the plug hole accurately. Care should be exercised in firing them to the correct degree of vitrification to prevent their chipping when being placed in position and to avoid spalling when they are hit by the stream of molten metal. All sandy material should be removed before shipment, for this, as well as spalls and chips, may cause serious nonmetallic inclusions in the ingot.

IX. Other Refractory Applications

Refractories play an important part in the economic and efficient operation of a steel plant in many places other than the furnace shop. Many of the problems encountered are similar, and will be discussed briefly in routine order through the mill.

(1) Soaking Pits

Soaking pits usually have fireclay roofs or covers of suspended or sprung-arch construction. While the temperature is not as high as in some other fireclay applications, the brick must be well bonded to prevent loosening, due to the shock of moving the covers at frequent intervals, or spalling, due to alternate cooling and heating as the pit is opened or closed.

Side walls of soaking pits are built of fire clay, "Yough" silica brick, or silica stone. Any material used must resist spalling and withstand the abrasive action of ingot movement into and out of

the pit. Scale from the ingots has a fluxing action, and consequently the bottom side walls are usually built of chrome brick, which resists slagging. Bottoms are made of coke, which is readily and cheaply replaced and which maintains a reducing atmosphere in the pit. Checkerwork is subject to some slagging and to failure under load, although neither problem is as severe as in the case of open-hearth furnaces, since temperatures do not run as high.

Insulation may frequently be used to advantage in soaking-pit construction especially around checker chambers and flues, although ordinarily the thickness of the side walls is sufficiently great to eliminate the need of additional material at those points.

(2) Reheat Furnaces

Fireclay refractories have wide application in reheat furnaces. In the case of roof construction, which may be either of the suspended or sprung-arch type, the material must be resistant to spalling, fusion, and a certain degree of loading. Spalls or drops of fused refractory material from the roof or joints may stick to the billets and cause surface defects in subsequent rolling operations, and provision must consequently be made to guard against such a possibility. Side-wall refractories must withstand load and resist spalling, particularly in the case of material used in door arches.

Several refractory materials are in use for reheat-furnace bottoms. They must resist the abrasive action of billets, etc., being pushed through the furnace and at the same time withstand the fluxing action of the scale. In some cases, to reduce abrasive action and the chance of bottom pick-up with the formation of "rolled-in" inclusions, steel skids, sometimes water-cooled, are installed in the furnaces. In other instances, plates of silicon carbide or Alundum have been used in locations where heavy wear must be withstood. Ordinarily, however, reheat-furnace bottoms are constructed of fireclay brick, silica, chrome-base plastics, etc. It may be noted in connection with refractory selection in furnaces of this type that insulation can be used profitably.

(3) Forging Furnaces

In the case of forging furnaces, both side walls and roof are usually constructed of fire brick and insulated if possible. Fire brick, chrome plastics, etc., are commonly used for the bottoms. Refractory failures ordinarily are due to spalling or abrasion. As is the case with practically all furnaces, spalls, drip, or bottom pick-up may cause serious trouble after the steel leaves the furnace, and refractories must be selected carefully to avoid the possibility of making the furnace a source of difficulty in this regard.

(4) Heat-Treating Furnaces

As most heat-treating furnaces are operated at medium temperatures, fireclay or insulating firebrick refractories are used in practically all cases. Each furnace must be studied individually, for the wide variation in size, shape, fuel, and design makes it impossible to say that any one material will be best under all conditions. Likewise, insulation can be used profitably in connection with most heat-treating furnaces, which will of course have a bearing on the refractory selected.

Refractory failures are usually due to spalling or mechanical abrasion, although load and fusion failures may occur if too low a grade of refractory has been installed. Economic considerations, however, normally govern the selection of refractories, service life being balanced against cost. Recently, the increasing use of gas atmospheres for controlling decarburization and scaling has become important to refractory engineers, as fire brick and insulating brick are disintegrated by the carbon deposits frequently formed in furnaces operated under controlled atmospheres. Operators are insisting upon longer refractory life, and studies are being made to overcome the problem most economically.

X. Conclusion

Although only the high spots in refractory selection and use have been touched in this paper, the principal problems confronting the steel producer have been outlined. Specifications strictly limiting or refusing to accept steel with nonmetallic inclusions are being urged by many steel consumers. The steel producer is doing everything in his power to improve the quality of his product and is willing to coöperate with the refractory manufacturers in an effort to develop new or improved materials which will stand up under the severe service imposed in steel-making operations and which will aid in improving the quality of his steel.

The Timken Steel & Tube Company
Canton, Ohio

NOTES ON REFRACTORIES FOR THE ELECTROTHERMIC ZINC INDUSTRY*

By Winfield B. MacBride

Abstract

The furnaces now in use for the electrothermic smelting of zinc at the Josephtown smelter are described and the type of charge used and the slag encountered discussed.

The refractory problems and the difficulties met with commercial brick are enumerated. A low-alumina refractory having a low porosity has given the best service for these furnaces. Various types of refractories were tried; for example, high alumina, silicon carbide, and magnesite. After an extensive series of tests, it was determined that the refractories should meet the following conditions: (1) low porosity to prevent evil effects of zinc penetration, (2) high melting point to prevent softening, (3) high electrical resistance at high temperatures, and (4) resist spalling and gradual disintegration due to slag, vapor, or gas.

Since refractories that suit these qualifications could not be readily obtained a few years ago, and since it was believed that many types of refractories and refractory mixes would be tested before arriving at something suitable, this company manufactured its own shapes for testing purposes. The results of these tests are given.

I. Introduction

In the experimental work leading to the development of the successful electrothermic-zinc furnaces now in use at the Josephtown Smelter of the St. Joseph Lead Company, it was found that electrical features of the furnace introduced more than the usual limitations in refractories. To understand these problems, a description of the electric furnaces, together with the charge now in use at this smelter, is necessary.

(1) The Furnace

The furnaces are the resistance type, the charge acting as the resistors. To facilitate easy movement of the charge and to provide for continuous operation, the furnace is vertical, 57 inches in diameter and approximately 30 feet in height, forming a huge retort. The wall of the furnace is composed of circular sections of refractories supported on steel skew rings. These rings are electrically insulated from the furnace columns. Electrical contact with the charge is made by means of three pairs of carbon electrodes, one of each pair placed near the top, the other placed near the bottom of the furnace, exactly opposite one another, one pair so placed as to provide an electrical path through the center of the charge. Each of these furnaces consumes about 1300 kilowatts, operates continuously, and contains about 20 tons of charge with a treatment capacity of about 35 tons in 24 hours. The normal operating temperature of the furnace is 1150° to 1200°C.

To conserve heat, supplied electrically, a horizontal rotary preheater with a refractory lining is used for the initial heating of the charge to approximately 800°C. From the preheater, the charge is fed directly into the furnace through a

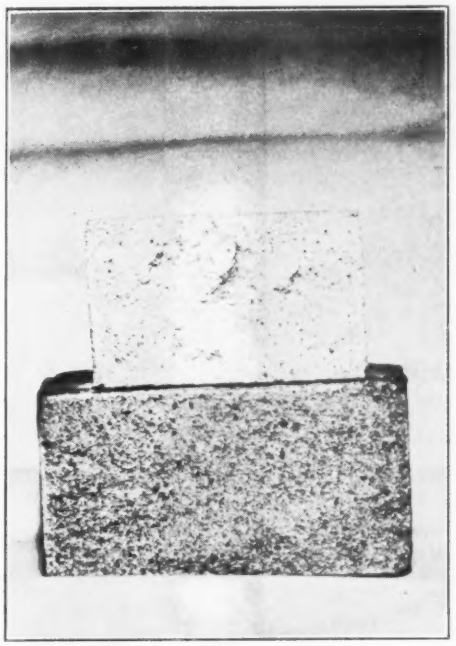

Fig. 1.—Comparison of low-alumina refractories: (*upper*) cross-section of shape now used; porosity, 14 to 16%; note hair-line cracks in surface; (*lower*) cross-section of refractory made by ramming with air hammer, and slowly filling mold; note uniform texture and absence of cracks (apparent wide difference in color due to sensitivity of photographic plate); porosity, 18 to 20%.

* Presented at the 1935 Summer Meeting, Refractories Division, American Ceramic Society, State College, Pa., September 20, 1935. Received September 28, 1935.

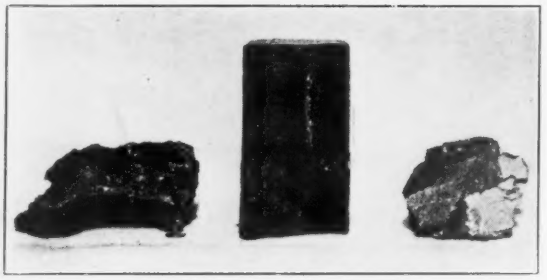

FIG. 2.—Effects of zinc impregnation on silicon-carbide refractories: (*left and right*) marked disintegration in a dome brick; (*center*) solidified zinc in center of brick which condensed after passage through pores of refractory.

rotary distributor. Passage of the charge through the furnace is controlled by a rotating table at the bottom of the furnace.

(2) The Charge

The charge supplied to the furnace consists of two separate elements, sized zinc sinter and sized coke. The principal slagging elements affecting refractories are iron oxides and iron-zinc silicates, coming within the sesquisilica range as shown on Hoffman's[1] constitutional diagram, with a fusing temperature of about 1120°C.

The sinter is prepared on Dwight Lloyd sintering machines and sized for use in the furnaces. The coke is crushed, sized, and mixed with the sinter in definite proportions to complete the charge. The sinter and the coke are very porous, and together they make a loose, porous mass in the furnace and allow the vapors to pass freely. The coke has a double function in that it provides the resistance path for the electric current and the carbon for the reduction of the zinc.

II. The Refractory Problems

The major refractory problems to be overcome are caused by silica and iron solution attack of refractories at high temperature, expansion, porosity, gradual disintegration (due to zinc penetration), and cost. An additional problem which sometimes arises involves constructional difficulties with special shapes which have not been manufactured to exact dimensions.

The expansion problem was practically eliminated by building the furnace in annular sections. As low-alumina fireclay refractories had been used in the zinc industry quite extensively, it was only natural that the first experiments be conducted with refractories of this class.

In the early experiments some difficulty was found with shapes from the manufacturer that were not true to dimensions, and considerable cutting and fitting was necessary during construction. Since the shapes were special and not needed in any great quantities, they were made of stiff mud and were hand-tamped into molds. Due to the plasticity of the mix, the pieces were somewhat distorted on removal from the mold and further distortion took place during drying and firing. Refractories made in this manner were fairly porous and additional defects were found due to penetration of the zinc vapor. These defects will be discussed later.

The item of cost eliminated many refractories when tests indicated that the life in the furnace was no greater than low-alumina shapes.

The remaining problems are somewhat related and the discourse on one problem may overlap the others. After several runs of indifferent success with low-alumina refractories, it was decided to try other types. A fairly well-known high-alumina refractory of about 70% alumina content was tried in the furnace. It did not withstand abrasion from the charge as well as the low-alumina fire brick, and since there were no other advantages apparent over the regular fire brick it was discarded because of cost. A high-alumina rammed lining of monolithic construction was also tried, but this failed, probably due to abrasion of the charge on the monolith at a temperature when the chemical bond had softened but before the ceramic bond had been attained.

After this series of tests, it was fairly well determined that the refractory should have (1) a low porosity to prevent evil effects of zinc

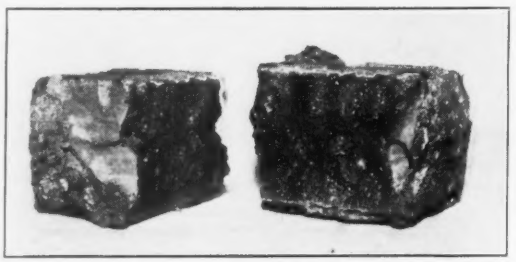

FIG. 3.—Effects of slag action on silicon-carbide refractory; specimen broken open to show pockets formed by slag.

[1] Collins, The Metallurgy of Lead, p. 153. Chas. Griffin & Co., Ltd., London, 2d ed., 1910.

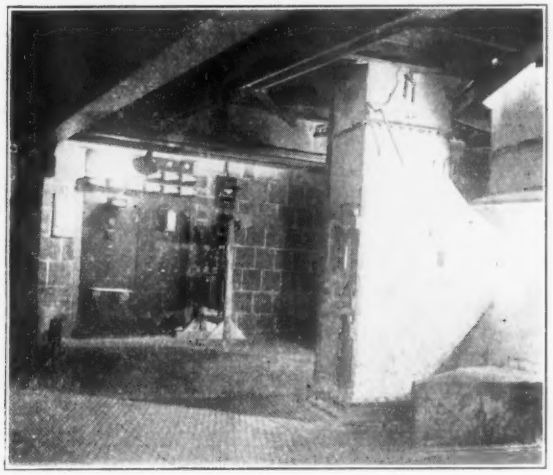

FIG. 4.—Furnace control switchboard and oxide manifold (furnace in operation).

penetration, (2) a high melting point to prevent softening, and (3) a high electrical resistance at high temperatures; it should also resist spalling and slag, vapor, or gas penetration.

III. Making Special Shapes

Since refractories that suited our purpose could not be readily obtained and since it was believed that many types of refractories and refractory mixes would be tested before arriving at something suitable, we decided to manufacture our own shapes.

(1) Equipment

Crushing and sizing equipment was installed for controlling grain size. Wooden molds of the various shapes were built and lined with $^1/_8$-inch galvanized sheets to withstand severe service. A humidity drier was installed with control for both temperature and humidity. A reverberatory kiln for firing the shapes was also built with an oil-fired dutch oven in each corner. Ports were built into the kiln at various places for pyrometric observation of the interior as it was found that temperature control by means of pyrometric cones did not indicate trends. As the temperature is held at approximately 1430°C for several hours, it is obvious that the temperature may reach this value, melt the cones, and then change to a lower value without becoming evident.

(2) Porosity Control

Proper grain control would not give lower porosity unless the grains were arranged compactly and uniformly either by considerable working or tremendous pressure. To achieve this end, air hammers were used to ram the material in the molds. This process involved considerable labor, as the molds were slowly filled by one man and continuously tamped with the air hammer by another. This slow process, however, resulted in a uniform grain structure in the brick, the porosity being 2 to 4% lower than in a power-pressed brick.

IV. Low-Iron Magnesite Refractory

A low-iron magnesite refractory was considered as best meeting the requirements for experiments on a commercial scale. About 25 mixes were developed and given porosity, spalling, visual, and other tests to determine the soundness of the shapes. After selecting the best mix, a complete set of shapes was made and installed in the furnace.

In the first few hours of the first run, there were indications that this refractory would successfully serve the purpose. After several days of operation, the pyrometers on one side of the furnace indicated an unbalanced condition due to excessive temperature. As each pair of electrodes had an independent voltage control, the current was reduced on the electrodes nearest

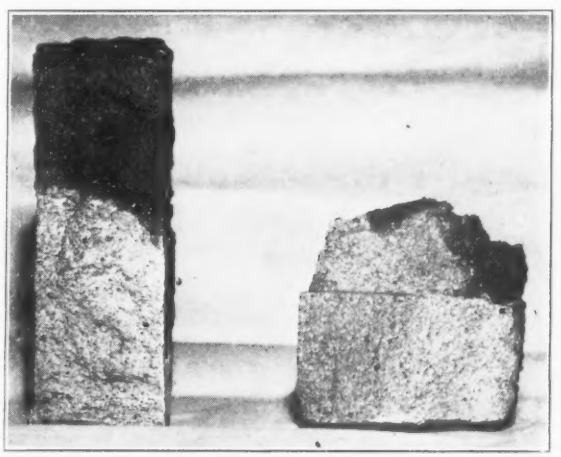

FIG. 5.—Low-alumina furnace refractories; refractories from side walls of furnace: (*left*) note zinc penetration in upper part of brick and metallic particles in zone near unaffected portion; (*right*) refractory from "gutted" portion of furnace; thin dark surface at right is surface-penetrated by zinc; deterioration is too rapid for further zinc penetration.

the hot spot and the furnace for a time was brought under control. The hot spot then returned and was more difficult to control the second time. This cycle occurred a few times and then went out of control, necessitating a shut down.

Gouging of the lining usually occurred with this condition, but the furnace lining was not gouged or fused in proportion to the difficulties encountered.

Such repairs as were deemed necessary were made and another run was made, with the same results. After a third run, three or four small holes were noticed in the lining of one of the annular sections. Only a shell, an inch or two in thickness, was left of the once solid wall. The

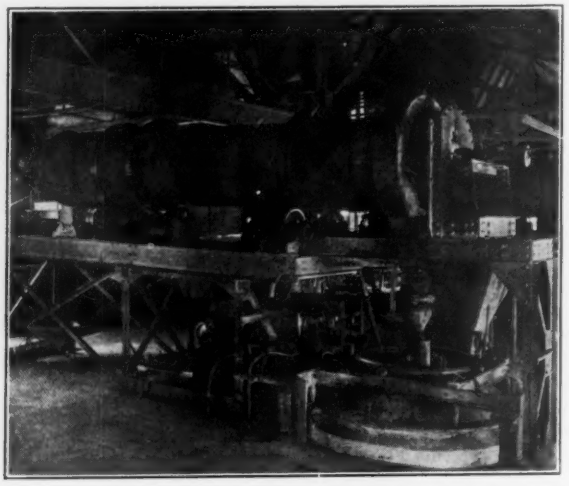

FIG. 6.—Preheater and charge distributer.

conclusion was then reached that the magnesite lining was carrying much of the electric current at high temperature. Subsequent tests have shown that there is a sharp decrease in resistance in magnesite brick near 1200°C and that the brick decreases in resistance under prolonged heating.

V. Low-Alumina Refractory

After these failures, it was then decided that the low-alumina refractories be improved. Many mixes were tested and one was finally evolved of low-alumina grog (ground to pass a 10-mesh screen with a control on the mount of −100-mesh material), a ball clay, and about 9 to 10% of water. These shapes were fired to 1430°C. They had a porosity of about 21%. The texture was very uniform and the refractory had a metallic ring when struck with a hammer.

We have not yet found a satisfactory substitute for the low-alumina fireclay refractories. The mix used is substantially the one developed several years ago. Improvements have been made in porosity, which now averages 14 to 16%.

VI. Why Porosity Control Is So Important

Low porosity is an important feature in any refractory used in the type of furnace described. The temperature of reduction is 1000° to 1200°C, depending upon the proximity of the carbon and zinc oxide of the charge. The boiling point of metallic zinc is 905°C. It is obvious that the inner wall of the refractories will be somewhere near the operating temperature of the furnace.

Since the furnace operates under a slight pressure, the vapor penetrates the pores of the brick and sometimes sets up a condition which results in the destruction of the refractory. The vapor on passing into the refractory progresses to a zone where the temperature conditions are low enough to cause condensation. This flow slowly continues until this zone is saturated with molten zinc.

Since refractories are never maintained at an exact temperature, this liquid zone changes its position. When the furnace temperature increases this liquid zone moves toward the outer face of the furnace wall. With a decrease in furnace temperature, the liquid zone will then move toward the inner face of the wall, leaving a zone of solidified zinc. With a subsequent increase in temperature, the liquid zone will again move toward the outer face, heating and liquefying the solidified zinc. Since zinc, in common with most substances, expands on heating and since the coefficient of expansion of zinc is greater than that of fire brick, definite strain is placed on the individual grains of the refractory. This tends to separate them. As this cycle may be repeated many times during a run, it is apparent that zinc penetration has an effect on the life of a refractory.

Another effect of zinc penetration is to lower the electrical resistance of the refractory with the likelihood of uncontrollable hot spots.

The size of the pores also has a bearing, since two different refractories may have the same porosity and yet be entirely unlike in pore structure. The one may have uniformly small pores

and the other a number of large pores concentrated at some zone. Saturation of this large pore zone by zinc would set up disruptive forces within the brick resulting in complete destruction.

VII. Experiments with Other Refractories

Since the erection of the Josephtown plant, several other refractories have been tested in the commercial furnaces. A monolithic rammed lining of mullite has been tried but since it is not possible to fire this type of lining uniformly it was destroyed by spalling.

Silicon carbide has also been tried as a lining material. The high iron slag, which accumulates as the reduced zinc is eliminated from the charge, rapidly disintegrates the silicon-carbide refractories in the lower zones of the furnace. The low electrical resistance of silicon carbide at high temperature is also a disadvantage.

Some tests on cast mullite refractories have been made and they now are being used around the top of the furnace. Whether or not they will prove entirely successful in this type of furnace is not yet apparent. A few shapes have been made of evacuated clay and the indication is that they are better on our class of service.

VIII. Conclusion

The type of furnace discussed requires a refractory having high electrical resistance at high temperature, low porosity, resistance to disintegration from the effects of CO gas, refractory compositions resisting the high iron silica slags, freedom from spalling, abrasion resistance at high temperature, shapes made reasonably close to drawing dimensions, and low cost. Some of these conditions have been met to a certain degree, but there is still much to be accomplished.

St. Joseph Lead Company
Zinc Smelting Division
Josephtown, Beaver County, Pa.

HOW THE CONTINUOUS ENAMELING FURNACE AFFECTS COPPERHEADS*

By H. L. Cook

Abstract

Possible reasons are given for the more frequent appearance of copperheads in continuous furnaces than in box furnaces and suggested operations for better preparation of metal for enameling are discussed.

I. Introduction

It has been assumed that copperheads are a defect that could be overcome by proper frit composition, but it is also recognized that certain heats used would cause copperheads under any plant conditions. The ground coat, in our plant, would fire without copperheads in the box-type furnace, although it developed copperheads in the continuous furnace. The ground coat apparently sealed over faster in the box-type furnace and further oxidation of the metal did not take place.

During the past three years, the copperheading tendency has become more pronounced. Experts on metal cleaning, frits, and enameling iron studied the problem and agreed that the difficulty was caused "somewhere in the pickle." Two years of pickle-room research failed to substantiate this statement, for frequent changes in every pickle material were made. Solutions were purposely allowed to grow old, pickling practice was good or bad, but copperheads continued to appear on the ware.

II. Experimental Treatment

Since the ware with the most pronounced black scum invariably copperheaded worse than brighter metal, it was decided to eliminate the various pickling baths on different lots of the same ware to see where the black scum formed.

A number of interior door pans with a decided copperheading tendency were chosen for the test, and a ground-coat enamel was chosen which, until six months before the test, had been used with excellent results except for the stray lots of metal which would copperhead. At the time of this test, an enamel mixture was being used with a higher absorption power for the copperhead-

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division).

producing constituents, but it was decided that this enamel would not do for the test.

Instead of eliminating the metal cleaner, the pans were cleaned entirely of oil in a trichloroethylene vapor cleaning machine. The pans were divided into the following groups: (1) no further treatment, not even slight rust spots removed; (2) 15 minutes in boiling cleaner solution, followed by thorough rinsing; (3) 15 minutes in 7% sulfuric acid at 140°F, followed by thorough water rinsing only, and fast drying; and (4) 5 minutes in the neutralizer bath.

The pans were intermingled, dipped in ground coat, dried, and fired in an electric continuous furnace. The pans receiving the acid pickling (group 3) were the only ones to copperhead.

The next test was to clean the pans in the same vapor machine and to pickle in the acid only 5 minutes. The copperheading in this test was greatly reduced and the pans, cleaned and pickled for 30 seconds in acid, were free of copperheads when fired.

Pans of this same group, when cleaned in the commercial metal cleaner and rinsed well, fired out almost free from copperheads.

With these results as a basis for further tests, the ware which had shown a copperheading tendency was run by using a 30-second acid pickling, all other pickling procedures being standard.

A slight evidence of copperheads was still present and the rusty ware had to be pickled longer than 30 seconds.

Shands[1] used sodium cyanide in an alkaline solution as a rust preventive. It was decided, therefore, to use the regular pickling practice but to neutralize the test pans in an alkaline solution of sodium cyanide instead of the standard neutralizer. The standard cyanide solution was 1 ounce of sodium cyanide, 1 ounce of soda ash, and 1 gallon of water; temperature 160°F; immersion time, 5 minutes.

The pans tested with this solution showed no copperheads. These tests were repeated many times and tests were also made on ground-coat enamels that previously had shown bad copperheading. In each test, perfect pieces of ware were obtained. Attempts to shorten the immersion time or to weaken the solution again produced copperheads.

At this time, the use of a nickel bath after the pickle was contemplated, although the nickel pickle had not generally been credited with prevention of copperheading. The standard nickel solution was prepared, the pans were treated, dipped, and fired, and no copperheads resulted with any of the ground coats used.

Since this test, the nickel pickle has been standard practice.[2] Ground-coat enamels which could not be used successfully before this test are now available for use. Nine commercial enameling irons have been enameled successfully in production quantities. Copperheads have appeared only once, and that time as a result of poor pickle-room control. Only one small lot of enameling iron has copperheaded, and this was corrected with a 30-second acid pickle and the standard nickel pickle.

A standard, electric U-type continuous furnace is used at this plant. The furnace is sealed tightly and, although the idea that it might contain harmful gases seemed plausible, exhaustive tests showed that no appreciable amount of harmful gases could be found. It was then vented, but no change in the furnace atmosphere was noted.

Standard pickled ware without nickel or cyanide treatment, when run through the vented furnace, suffered a 20% loss due to copperheads, indicating that furnace-venting is wasteful of heat and under no circumstances is it effective in correcting copperheading.

III. Summary

(1) Copperheads can be decreased with the use of proper frits. A frit, however, with a high affinity for oxides and other impurities may show other weaknesses.

(2) Certain heats of enameling iron are more conducive to copperheading than others.

(3) Often a treatment of 30 seconds in the acid pickle or elimination of the acid pickle will greatly minimize copperheading. This is usually associated with fast pickling irons, and the theory seems plausible that excess oxides and salts are produced by long pickling in this type of iron.

(4) The use of sodium cyanide in the neutralizing bath as a preventive of copperheads indicates that ferrocyanides are produced from the excess oxides.

[1] E. H. Shands, Detroit Vapor Stove Company, communicated statement.

[2] See also J. E. Hansen and J. T. Irwin, "Use of Nickel Dip in Enameling Practice," *Jour. Amer. Ceram. Soc.*, **18** [8] 225–29 (1935).

(5) The use of sodium cyanide is not recommended since it is very poisonous, especially in conjunction with sulfuric acid.

(6) Furnace venting has a distinct effect in addition to the elimination of gases. The oxidizing rate[3] of the ware is slower in a vented furnace. The ware reaches its peak temperature at about the same place in a furnace whether it is vented or sealed. The ware on the ingoing side of a vented furnace, however, is cooler than the ware on the same side of a tight furnace. Iron, which has oxidized more readily in the process before firing, is oxidized past the danger point in a furnace with a high oxidizing rate.

IV. Conclusions

Box-type furnaces seal over the metal more rapidly than do continuous furnaces, and the ware thus fired has fewer copperheads.

With the use of the continuous furnace, a new set of firing conditions and problems has opened up and, as a result, the pickling practice used for box furnaces is not satisfactory for continuous furnace firing.

Although copperheading was eliminated by the study presented here, it is not known why longer acid pickling causes copperheads or why sodium cyanide neutralizer decreases copperheads.

Norge Corporation
Division of Borg-Warner Corporation
Muskegon Heights, Michigan

[3] H. E. Ebright, G. H. McIntyre, and J. T. Irwin, "Study of Furnace Atmosphere and Temperature Gradient and Their Effect on Porcelain Enameling," *Jour. Amer. Ceram. Soc.*, **18** [10] 297–302 (1935).

ERRATUM

In H. Masukowitz, "Electric Firing of White Porcelain," *Bull. Amer. Ceram. Soc.*, **14** [10] 337–41 (1935) the translator's note on page 341 should read as follows: "In the conversions, the Reichsmark has been figured at 2.5 to the dollar, and the ton at 2000 lb."

ACTIVITIES OF THE SOCIETY

MEMBERSHIP SOLICITATION

New members received prior to January 1, 1936, will be enrolled as of 1936, but will receive the December issues of (1) *The Journal*, (2) *Ceramic Abstracts*, and (3) *The Bulletin*, each of which will contain its respective indexes.

New members received prior to January 1, 1936 may purchase the 1935 publications at the 20% discount enjoyed by members on previously issued publications.

No "continuation" educational opportunity is available other than by membership in the American Ceramic Society.

The ceramic technologist who does not study the rapidly advancing art and science in all ceramic industrial branches is not equipping himself to the fullest for service in the particular line of his employment.

No way is possible of keeping abreast and broadened other than membership in the American Ceramic Society.

Extending an invitation to join in this coöperative "continuation" and broadening educational enterprise is rendering a kind and thoughtful deed.

The supporting of this Society by corporations by payment of a minimum of $25.00 annually, thus making possible a larger educational activity than can be financed by personal dues, is a profitable investment. Without the American Ceramic Society, in and through which the ceramic arts, science, and technology are promoted, the ceramic industries could not hold their own in competition with the many and new nonceramic products.

Let us make this Society better able to achieve definite results. This can be accomplished by a larger membership.

At what cost can one privately and alone abstract the world-wide literature of value to him? This the American Ceramic Society is doing for ceramists.

Personal Memberships $12.50
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ABUNDANT CERAMIC LIFE?

Nixie—not until 2000 Personal and 500 Corporation members are taking advantage of the privileges afforded by the American Ceramic Society.

Here are the statistical facts:

	1934	1935	Gain
Personal members	1228	1297	+ 69
Corporation members	169	186	+ 17
Deferred payment	47	29	− 18
Subscribers	437	442	+ 5

Progress has been slowly made. Will each member assist in accelerating the progress to that membership strength by which can be had that "Abundant Ceramic Life."

What about more application cards?

NEW MEMBERS

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JOHNSON, FRED M., 1920 Upton Ave., Toledo, Ohio; sales engineer, Surface Combustion Corp.

NEAD, JOHN H., Inland Steel Co., E. Chicago, Ind.; chief metallurgist.

Student

BERKELHAMER, LOUIS H., College of Mines, University of Washington, Seattle, Wash.

CONDOS, MITCHELL G., University of Alabama, University, Ala.

FRINGS, RAY F., University of Alabama, University, Ala.

HOH, SHAI-KWONG, Alfred University, Alfred, N. Y.

NILE, ROBERT H., Ohio State University, Columbus, Ohio.

PETERS, JOSEPH D., Ohio State University, Columbus, Ohio.

RUSS, ARTHUR A., Alfred University, Alfred, N. Y.

SCHIEFFERLE, JAMES, University of Alabama, University, Ala.

TOOLEY, FAY V., University of Illinois, Urbana, Ill.

WARDE, JOHN M., Montana School of Mines, Butte, Mont.

WHITE, MILO A., JR., Rutgers University, New Brunswick, N. J.

MEMBERSHIP STATUS

	October 25	November 20
Paid in full		
Personal	1209	1221
Corporation	186	186
Honorary, Life, and Complimentary	26	26
Deferred personal	33	29
Part-payment personal	51	50
Subscribers	442	444
Advertisers	35	35
Current Sales	225	225
TOTAL	**2207**	**2216**

MEMBERSHIP WORKERS' RECORD

Personal

E. L. Hettinger	1	M. E. Holmes	1
C. B. McComas	1	T. N. McVay	4
R. J. Montgomery	1	C. W. Parmelee	1
F. R. Porter	1	H. E. White	1
Student		Hewitt Wilson	1
G. H. Brown	1	Office	1
J. L. Carruthers	1	**GRAND TOTAL**	**15**

NECROLOGY

CHARLES H. WALKER

After an illness of three years, C. H. Walker, General Superintendent of the Homer Laughlin China Co., Newell, W. Va., died at his home in East Liverpool, Ohio, on Wednesday, October 30, at the age of 60 years.

Born at Stoke-on-Trent, England, Mr. Walker was reared in the Staffordshire district. He was apprenticed in the pottery business before he was 14 years of age and became familiar with every branch of the industry. For many years he was employed by the Ridgeway potteries.

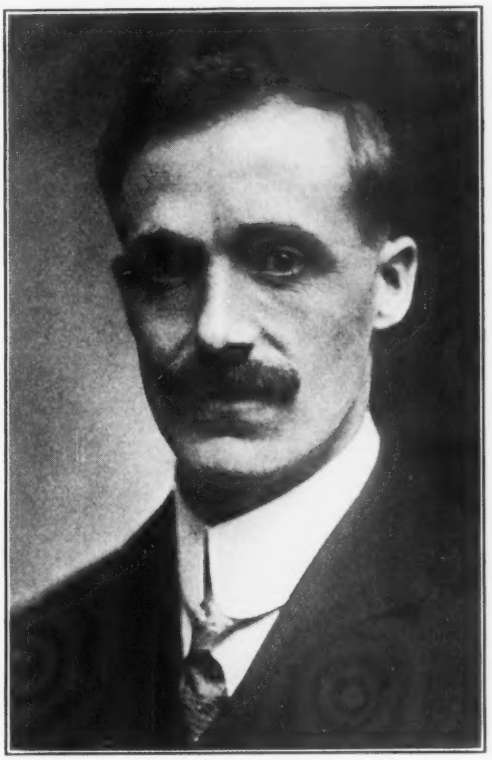
Coming to the United States in 1905, he became associated with the Homer Laughlin China Co., which then operated three plants in East Liverpool and had just completed the No. 4 plant at Newell. He later became superintendent of all these plants which are now centered in Newell.

For many years Mr. Walker was a member of the Research Committee and the Western General Ware Standing Committee of the U. S. Potters Association. In his dealings with the thousands of pottery workers with whom he came in contact, he was known for his fairness in trade disputes, winning the admiration of operatives and plant owners. He was a man of outstanding integrity and honor in all of his dealings.

Mr. Walker was a noted expert of the pottery industry, thoroughly familiar with all of its aspects and ever ready to accept new developments when they appeared to him to be sound in principle. He was first in the district to introduce casting with the use of alkalis, to make cast saggers, and to systematize tunnel-kiln operation for the general ware business.

He had been a member of the American Ceramic Society since 1911 and was honored by election to its Fellowship.

The departed leaves his widow, Mrs. Maud Walker, one daughter, Miss Olive Walker, three brothers and two sisters. His loss is a severe blow not only to his family and associates but also to his firm and his industry. His calm judgment, kindliness of heart, loyalty and generosity will be sorely missed.—A. V. BLEININGER



Charles H. Walker

MRS. ROBERT D. LANDRUM

Members of the Society will regret to learn that Mrs. Robert D. Landrum passed away on October 30. Prior to her illness she was a regular attendant at the Meetings of this Society and by her graciousness and friendliness she earned the affection and friendship of many of our members and their wives.

FRED L. DICKEY

Fred L. Dickey, President and General Manager, W. S. Dickey Manufacturing Co., Kansas City, Mo., died November 11 after a brief illness. He was 60 years old.

Mr. Dickey, a brother of the late W. S. Dickey, had been associated with the clay manufacturing business, set up by his father, almost continuously since entering business.

During the receivership and trusteeship of the Dickey Company, before its reorganization in 1934, he served as General Manager and also as a Trustee.

Mr. Dickey had been a member of the American Ceramic Society since 1913.

WANTED: CONTRIBUTIONS TO AMERICAN CERAMIC SOCIETY LIBRARY

The library of this Society has the Third to the Eighth editions of the Ceramic Equipment and Material Catalogs and Ceramic Products Cyclopedia, now called the Ceramic Data Book with Equipment and Material Catalogs. These publications are issued by Industrial Publications, Inc.

Because of the increasing number of requests for the earlier editions, the Society would appreciate receiving copies of the first two editions.

Anyone who has the earlier editions and will contribute them to the American Ceramic Society will be accommodating many who are now using this library.

CERAMIC WARE FIRING

A Ceramic Ware Firing Symposium will be held at the Annual Meeting of this Society in Columbus, March 29 to April 4, 1936. Your participation is desired.

Emphasis will be laid on the reasons for more exact firing of ceramic ware.

Where Difference in Flame Length Is Required

Firing of tunnel kilns requires shorter flames, as does the firing of small kilns. Periodic kilns and chamber kilns of industrial size differ from tunnel kilns in their firing only in the necessity for uniform heating over a longer distance by using longer flames.

Necessity of Convection

Uniform firing of ceramic ware is said to have been developed to successful plant operation with no dependence upon convection of combustion products through the ware setting in tunnel muffle chambers.

Electric Firing Successful

Electric kiln firing in Europe and also by the T.V.A. at Norris, Tenn., has been developed to claimed industrial success.

Questions

Convection

To what extent is the uniform firing of ware dependent upon induced convection in muffle tunnel and in electric kilns?

Secondary Air in Tunnel Kilns

In muffle tunnel kilns, what dependence must be placed on secondary air to obtain the length of flame required to heat all sides of the muffle uniformly?

Uniform Heat Treatment

In firing of clayware, how important is it that the entire structure of the ware be uniformly heated and brought uniformly to its required degree of fusion?

In glost firing of clayware and in the enameling of metals, how important is it that all surface parts of the ware shall be heated uniformly?

Annealing

Should not the producers of clayware and vitreous enamelware be as much concerned with the rate of cooling of their ware in the kilns and ovens as are the glassware producers in the annealing of their products, and much for the same reasons?

Long Flame Requirements

Where long flames are required, as in periodic and chamber kilns of industrial size, the conclusions of *U. S. Bur. Mines Tech. Paper*, No. 137 (1917), "Combustion in the Fuel Bed of Hand-Fired Furnaces," by Henry Kreisinger, F. K. Ovitz, and C. E. Augustine are pertinent.[1]

To what extent do the conclusions in that report controvert the statement by H. E. Nold in the *A.I.M.M.E. Tech. Pub.*, No. 509 on "Uses of Coal in the Ceramic Industry"?

Are those conclusions in harmony with those by Bole, Blizard, Rice, Ogden, and Sherman in *U. S. Bur. Mines Bull.*, No. 271, "Problems in the Firing of Refractories," pp. 151, 159, and 160?

Statements Quoted in Contrast

(From *Tech. Paper*, No. 137, pp. 8-9, Summary of Results and Conclusions.) "The fuel bed in most types of furnaces acts primarily as a gas producer. With a 6-inch fuel bed, the oxygen in the air rising through the grate is all used for combustion in the first 4 inches from the grate. At a distance of 4 inches from the grate, the carbon dioxide content of the gases has reached or passed a maximum of 10 to 16 % and begins to drop. At the surface of the fuel bed, the gases contain no oxygen, only 6 to 8 % of carbon dioxide, and 20 to 32% of combustible gases. The composition of the gases is practically independent of the rate of air supply. The larger the quantity of air forced through the fuel bed, the faster the fuel burns or gasifies, but the ratio between weight of air supplied and weight of fuel burned remains constant at about 7 to 1.

"In general, the temperature in the fuel bed is the highest 3 to 5 inches from the grate, which is also the point of maximum carbon-dioxide content.

"A fuel bed is understood to be only the layer of incandescent and freshly fired fuel and does not include the layer of dead ashes and clinker on the grate . . . . .

"As at the surface of the fuel bed the gases contain 20 to 32 % combustible gas and practically no free oxygen, *to obtain complete combustion additional air must be introduced over the fuel bed.*[2] This statement is true of all the fuels tested, including coke. As a general statement, about one-half of the 15 pounds of air used to burn one pound of coal in a boiler furnace is supplied through the fuel bed; the other half must be supplied over the fuel bed.

"The results of the tests substantiate the statements made in the chapter on combustion of coal in *Technical Paper*, No. 80. . . . "

Where Combustion in a Furnace Takes Place

"Combustion of coal takes place partly in the fuel bed and partly in the space above the fuel bed which is commonly called the combustion space. The process of combustion in the fuel bed consists chiefly of the gasification of the fuel. The products of this gasification are mainly CO_2, CO, CH_4, and H_2. The combustible gases rising from the fuel bed are burned in the combustion space by uniting with the oxygen in the air admitted through the firing door or other openings specially provided for the purpose, and the combustion is complete if the supply of air and the

[1] See also *U. S. Bur. Mines Bull.*, No. 135.

[2] Italics not used in the original but used here for emphasis.

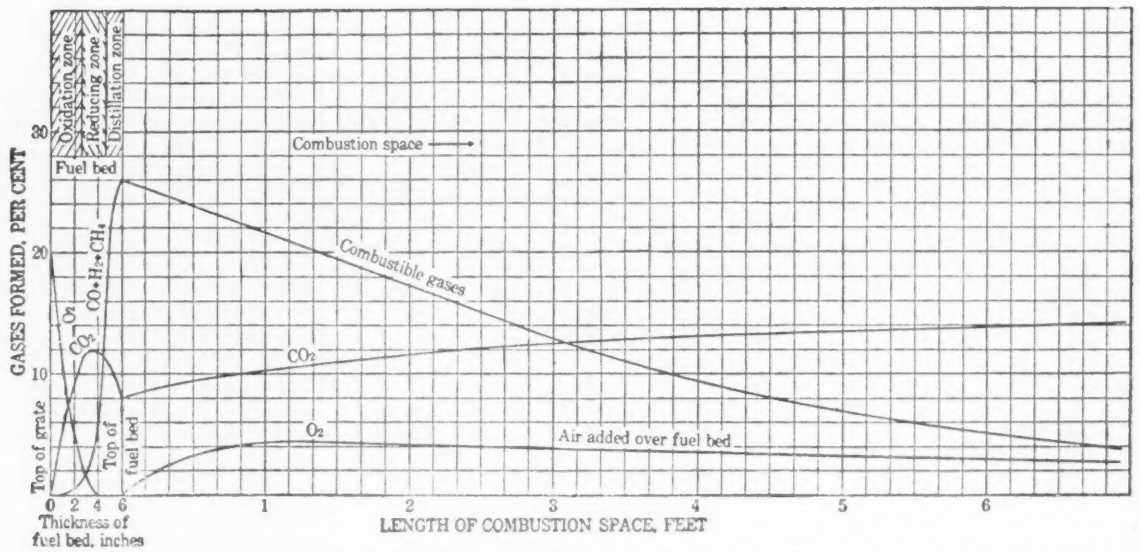


FIG. 1.—Composition of gases in the fuel bed and in the combustion space. The gases at the top of the fuel bed contain no free oxygen and a high percentage of combustible gases, which burn in the space beyond the fuel bed after oxygen has been admitted. This diagram is a generalization of the results of many tests. (Reprinted from *Bur. Mines Tech. Paper*, No. 137, p. 11, 1917.)

size of the combustion space are sufficient. The process of combustion in a hand-fired furnace is well illustrated by Fig. 1, which shows the percentages of the three principal gases at various distances from the grate.

"It is shown that in the fuel bed the composition of gases changes rapidly, whereas *in the combustion space the change in the composition is comparatively slow and gradual.*"[2]

Statement in Contrast

(From *U. S. Bur. Mines Bull.*, No. 271, p. 151 (1927).) "The combustion of coal in a fuel bed occurs in three stages. The first stage is the union of the oxygen of the air with the carbon of the coal to form carbon dioxide. *This reaction is rapid and takes place in the first few inches from the point of admission of the air.*[3] The second stage is the union of the carbon dioxide with more carbon to form carbon monoxide. The third state is the distillation of the volatile matter from the freshly fired coal at the top of the fuel bed. The volatile matter leaves the fuel bed in the form of various gaseous hydrocarbons and tar. The fuel bed is thus divided into three zones which, however, are not distinct, but overlap.

(*Ibid.*, p. 159.) "In samples taken over a short period, combustible gases were present only when oxygen was absent. *The gases burned almost as soon as secondary air was admitted to the gas stream; delayed combustion could therefore be had only by delaying the admission of the secondary air.*[4]

(*Ibid.*, p. 160.) "Although the combustion of the gases is so rapid, the combustion of the carbon particles, as has been pointed out, is very slow and extends throughout the kiln and possibly through the flues and stack. These incandescent particles of soot, together with ash, constitute the flames seen in the setting and often at the top of the stack. The heat liberated by the combustion of the soot within the setting is probably inconsiderable compared to that which would result from the combustion of the gases. . . . .

(*Ibid.*, p. 160.) "This transference of heat by radiation is one advantage of the use of 'long-flame' coals and 'long-flame' conditions in a brick kiln, or in any process that requires uniform temperature, when a large mass of the material to be heated is out of 'sight' of the fuel bed."

[3] This refers only to the primary air oxidizing coal within the fuel bed.

[4] Italics not in the original. This statement refers to combustion of the gases after they leave the fuel bed.

FUEL COSTS range from 2 to 4% of total production costs and only 13 to 25% of total firing costs.

COSTS OF IMPERFECTLY FIRED WARE range much higher than do fuel costs.

It pays to reduce ware loss and to improve ware quality by better firing, even at higher fuel costs.

ROSTER CHANGES DURING NOVEMBER*

Personal

BAKER, EARL B., 18597 Wood Ave., Melvindale, Mich. (Tiffin, Ohio)

BARRETT, ELLIOTT P., Mellon Institute of Industrial Research, Pittsburgh, Pa. (Mineral Industries Experiment Station, State College, Pa.)

BURROWS, O. MASON, Norton Co., Research Laboratory, Worcester, Mass. (Exeter, N. H.)

CANFIELD, RUTH E., 175 West Fourth St., New York, N. Y. (Henry St. Settlement)

COMMONS, CHARLES H., JR., 4621 Terrace Drive, Niagara Falls, N. Y. (1701 16th St.)

CRAIG, JAMES W., Canadian Refractories Ltd., 1050 Canada Cement Bldg., Montreal, Que., Canada. (Mines Branch, Sussex St., Ottawa, Ont.)

DUVALL, WAYNE H., 6106 University Ave., Jackson Park Sta., Chicago, Ill. (6620 S. Lowe St., Englewood Sta.)

ELLIS-ANWYL, R. H., Box 285, Hope, Ark. (Shreveport, La.)

FORD, KARL L., Stone House Farm, Durham, N. H. (Glass Container Assn., New York, N. Y.)

GILLINDER, JAMES, 136 E. Main St., Port Jervis, N. Y. (11 Orange St.)

HEWITT, L. C., 4705 Ridgewood, St. Louis, Mo. (1711 Ambassador Bldg.)

KIRKENDALE, GEORGE A., Canada Fire Brick Co., Montreal, Que., Canada. (Toronto, Ont.)

MCCANN, F. A., Catalina Clay Products, Avalon, Calif. (San Marino, Calif.)

MCCLOSKEY, PAUL, Frigidaire Corp., Dayton, Ohio. (Gallitzin, Pa.)

MCDONALD, C. H., West Brothers Brick Co., Washington, D. C. (Roodhouse, Ill.)

MALSCH, WERNER, 1611 Michigan Ave., Miami Beach, Fla. (Belmar, N. J.)

MASON, MAUD M., 290 Clinton Place, Hackensack, N. J. (Darien, Conn.)

OWENS, CHARLES W., JR., 118 Forest Road, Raleigh, N. C. (Box 3778, State College Sta.)

PHILLIPSON, EDWARD G., 120 Ave. E South, Saskatoon, Sask., Canada. (618 McPherson Ave.)

PORTER, FRANK R., 32 Highland St., Hammond, Ind. (Edison General Electric Appliance Co., Chicago, Ill.)

POSTE, EMERSON P., 309 McCallie Ave., Chattanooga, Tenn. (Box 4051)

SKINNER, KENNETH G., 4725 15th N. E., Apt. 38, Seattle, Wash. (Toppenish, Wash.)

STEVENS, ROBERT P., Acme Brick Co., Cayuga, Ind. (Danville, Ill.)

TETRICK, JAMES D., 15 Somerset Road, Catonsville, Md. (Baltimore Enamel & Novelty Co., Baltimore, Md.)

TREES, JACK E., 472 N. Philip, Detroit, Mich. (161 Chalmers St.)

* Address in parentheses is the old address.

CERAMIC EXHIBITS ADDED TO SOCIETY COLLECTIONS

W. S. GEORGE POTTERY COMPANY

"Petit Point" Tableware

The Society has recently received an exhibit from the W. S. George Pottery Co., showing its new "Petit Point" tableware.

These sets are in blue, green, yellow, and rust colors. A skeleton line in each of these colors consists of one each of tea cup and saucer, four-, five- and seven-inch plates, four-inch fruit, oatmeal, six-inch soups, seven-inch baker, seven-inch nappy, eight-inch dish, open sugar, and cream.

HAZEL-ATLAS GLASS COMPANY

Hazel-Atlas Tableware

The Hazel-Atlas Glass Company has sent a fine and extensive exhibit of tableware.

Blue, green, yellow, pink, and clear glassware are on display. Milk glassware banded with red and black is also included.

GLADDING, McBEAN & COMPANY

Franciscan Ware

A comport, vase, and a large plate have been received from Gladding, McBean & Co., as examples of its low-fired Franciscan ware.

These pieces show the clear, beautiful blue, yellow, and orange-red obtainable at cone 06. This exhibit has attracted appreciative attention of many persons who have visited the Secretary's executive office.

VERNON POTTERIES

Large Plates Received

The Society has received from Vernon Potteries two large plates in its new cone 06 line. The plates are decorated in vivid glaze colors.

RUTGERS UNIVERSITY

Glazed Vases

George H. Brown, Department of Ceramics, Rutgers University, has sent one large vase and several small vases, illustrating his most recent classroom work in colored glazes.

This is a unique exhibit.

BAUSCH & LOMB OPTICAL COMPANY

Historical Paintings Reproduced

Bausch & Lomb Optical Company has sent six reproductions of optical history paintings, the titles as follows:

(1) According to legend, spectacles were worn in the time of Confucius, 500 B.C.; Marco Polo reported them in general use in China about 1275 A.D.

(2) In Europe, from the 14th to the 17th Centuries, street vendors sold crude spectacles, both for adornment and as an aid to vision.

(3) In 1609, Galileo was acclaimed by distinguished citizens of Venice when he demonstrated his first telescope from the tower of St. Marks.

(4) A most significant event was the discovery of bac-

teria in 1675 by Antoni Van Leeuwenhoek, who used a primitive microscope of his own manufacture.

(5) Through his extensive experiments with light, Sir Isaac Newton (1642–1727) became one of the founders of modern optical science.

(6) Measuring his own eyes, Thomas Young conducted experiments in the years 1799 to 1801 that led to his explanations of astigmatism and accommodation.

OFFICERS OF SOCIETY FOR 1936 ARE NOMINATED

Two Nominating Committees of eight members each, appointed by the Divisions of the Society and acting independently of each other, place the following members in nomination: *President*, Francis C. Flint, Hazel-Atlas Glass Co., Zanesville, Ohio; *Vice-President*, Robert B. Sosman, United States Steel Corporation, Research Laboratory, Kearny, N. J.; and *Treasurer*, H. B. Henderson, H. B. Henderson Co., New Brighton, Pa. and C. Forrest Tefft, The Claycraft Company, Columbus, Ohio.

LOCAL SECTION NEWS

MICHIGAN-NORTHWESTERN OHIO SECTION HEARS G. L. CLARK

G. L. Clark of the University of Illinois addressed the Michigan-Northwestern Ohio Section of the American Ceramic Society Friday evening, November 22, at Flint, Mich. Dr. Clark showed X-ray applications adapted to all forms of engineering work.

The afternoon of the meeting members visited the spark-plug division of the A C Spark Plug Company at Flint. The various ceramic operations and the final assembly of the insulator into the shell were demonstrated. Thirty members were present at this meeting.

—MACON TRABUE, *Secretary-Treasurer*

PITTSBURGH SECTION HEARS DWIGHT BENNETT

The Pittsburgh Section of the American Ceramic Society met November 12. Dwight Bennett, of Mellon Institute, addressed the group on the subject of enamels.

Dr. Hicks of the X-ray Department, University of Pittsburgh, assisted Mr. Bennett. During the discussion it was shown that the X-ray can be of considerable assistance to the ceramist. Mr. Bennett explained a new shock test for cast-iron enamels.—EARL C. PETRIE, *Secretary*

STUDENT BRANCH NEWS

NEW YORK STATE COLLEGE OF CERAMICS

Plans for 1936 Are Made

J. T. Littleton, Corning Glass Works, addressed this Student Branch December 10, on glass technology. Plans for the St. Pat's Celebration next March are started; Curtis Jackson, a senior in ceramic technology, is Chairman of St. Pat's Board.

Members are also arranging for industrial trips in connection with the Annual Meeting of the Society in Columbus, March 29 to April 4.

PENNSYLVANIA STATE COLLEGE

R. A. Miller Addresses Group

R. A. Miller, Technical Sales Engineer, Pittsburgh Plate Glass Company, gave an illustrated talk on "Recent Developments in the Sheet and Plate Glass Industry," before members of the Student Branch, October 18.

He particularly emphasized the field of heat-absorbing glasses for exclusion of the infra-red part of the spectrum, thereby making a room cooler in summer and warmer in winter. Discussing the question of air conditioning, he mentioned the trend toward double glazing as a means of cutting down heat transfer.

The improvements made in polishing techniques resulting from better control of the rouge materials were also pointed out. The talk emphasized the value of scientific control in all phases of glass manufacture.

Abrasive Developments Described

Ross C. Purdy, General Secretary of the Society, visited State College, November 6, and addressed the Student Branch on the "Technical Advances in the Field of Abrasives."

UNIVERSITY OF NORTH CAROLINA, RALEIGH UNIT

Large Attendance at Opening Meeting

Six upperclassmen, transfers from other departments and colleges and nineteen freshmen were taken into this Student Branch at the annual initiation of associate members, November 5.

Officers for the year are as follows: C. W. Owens, Jr., *President:* R. B. Knox, Jr , *Vice-President:* S. G. Riggs, Jr., *Secretary:* and J. L. McLaughlin, *Treasurer.*

VIRGINIA POLYTECHNIC INSTITUTE

New Student Branch Formed

On recommendation of the Committee on Divisions and Sections, the Board of Trustees has granted the following petition:

"We, the undersigned, all regularly enrolled students in good standing of the Virginia Polytechnic Institute, wish to apply to the American Ceramic Society for permission to form a Student Branch of the American Ceramic Society, this branch to be called 'The Virginia Polytechnic Institute Student Branch of the American Ceramic Society.'

"All of the undersigned are students of the Ceramic Engineering Department of the above-mentioned school and intend to apply for membership in the American Ceramic Society in the near future."

Signed: R. S. Hall, Jr., A. M. Harvey, Jr., C. A. Vaughan, H. O. Biddle, W. S. Connelly, and J. W. Pierce, Jr.

This application was endorsed by the following members of the American Ceramic Society: J. W. Whittemore and R. S. Hall, Jr.

NOTES AND NEWS FOR CERAMISTS

National Paving Brick Association to Meet January 29 to 31

The National Paving Brick Association will hold its thirtieth annual meeting January 29 to 31, at the Deshler-Wallick Hotel, Columbus, Ohio.

Technical papers will be presented by highway engineers and experts who have been in charge of design and construction of brick pavements.

Sessions for plant operators covering the latest developments in de-airing will also be held. One feature of the meeting will be a trip to the experimental brick pavement now under construction on Ohio Route 31, thirty-five miles southeast of Columbus.—G. F. S.

Canadian Ceramic Society to Meet February 17 to 18

The thirty-fourth annual meeting of the Canadian Ceramic Society will be held at the Royal York Hotel, Toronto, February 17 to 18, 1936.

A paper on materials in modern construction will be presented. J. G. Phillips of the Ceramic Division will review recent developments. Other papers of ceramic interest are also being scheduled.

Ohio Ceramic Industries Association Meeting Well Attended

A total attendance of more than 150 was registered at the annual fall meeting of the Ohio Ceramic Industries Association held at Ohio State University, November 1 and 2.

General sessions of the Association, with members of all divisions present, were held Friday and Saturday mornings. Three sectional meetings were held Friday afternoon, with programs of interest to manufacturers of heavy-clay products whiteware, and refractories. The Ohio enamelers met Saturday morning.

Officers for the year were elected at the meeting. They are as follows: *President*, B. T. Bonnot, Bonnot Co., Canton, Ohio; *Vice-President*, W. Keith McAfee, Universal Sanitary Manufacturing Co., New Castle, Pa.; and *Treasurer*, C. Forrest Tefft, Claycraft Co., Columbus, Ohio.

Willi M. Cohn Discusses Solar Furnace

According to an item in *Time*, p. 35 (October 21, 1935), Willi M. Cohn, Berkeley, California, described the solar furnace invented in Germany at the recent meeting of the Electrochemical Society in Washington, D. C.

Used for high-temperature work, this furnace consists of a coelostat (a flat mirror geared to follow the sun) which feeds the rays into a concave reflector. From this they are sharply focused on the substance under treatment.

The furnace is used to make a kiln lining of zirconium oxide. One-half minute under the reflector melts the oxide at 4850°F.

Dr. Cohn states that it may be possible to attain temperatures as high as the surface heat of the sun itself, about 11,000°F, by increasing the mirror size and cutting down heat losses.

United States Potters Association Meets in Cleveland

The annual meeting of the United States Potters Association was held in Cleveland, Ohio, December 3, and 4, at the Hollenden Hotel. The annual dinner was held the evening of December 3.—CHARLES F. GOODWIN, *Secretary*

CERAMIC SCHOOL NOTES

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Bair and Wilson Complete Work

G. J. Bair has completed his work for a Doctor's degree in Ceramics and has returned to his duties at Pennsylvania State College, State College, Pa.

E. O. Wilson, who received his Doctor's degree in Ceramics last spring, has returned to Yenching University, Peiping, China. He is head of the Chemistry Department there and is carrying out an extensive program to develop the ceramic resources in North China.

Cayford, Whittaker, and Blakely Study for Doctorates

The following students are studying for a Doctor's degree in ceramics:

J. M. Cayford, who last year received a Master's degree at Ohio State University; Harry Whittaker, from Pennsylvania State College; A. M. Blakely, who received his Master's degree in Physics at the Massachusetts Institute of Technology last year; and R. N. Palmer, a graduate of Electrochemistry at Massachusetts Institute of Technology.

R. O. Lane and M. S. Tarnopol are studying for the Master's degree in Ceramics.

Ceramic Museum Adds New Pieces

The Ceramic Museum at Massachusetts Institute of Technology has added a number of new pieces this year. Some of them were contributed by F. H. Norton, objects collected while visiting European ceramic plants during the summer.—F. H. N.

NEW YORK STATE COLLEGE OF CERAMICS

More than Three Hundred Enroll in Ceramics

The New York State College of Ceramics opened this fall with an enrollment of 315 students, divided almost evenly between the departments of Ceramic Art, General Ceramic Technology and Engineering, and Glass Technology. All students in the two latter departments belong to the Alfred Student Branch of the American Ceramic Society.

The Ceramic Guild, composed of students in the Ceramic Art Department, recently held their annual Christmas Festival at which pottery and other ware made by the students were displayed and sold.

Research Projects Listed

Some of the research projects which the seniors have under way are as follows:

1. "Effect of washing green and biscuited whiteware with slips of flint, feldspar, etc., before applying the glaze."
2. "Molybdenum plating of steel for enameling."
3. "Cold-patching material for enamels."
4. "The use of waste materials from the magnetic separation of feldspar."
5. "Tensile-strength factors for ceramic oxides."
6. "Compilation of a table of standards for X-rays."
7. "Investigation of results of substituting cristobalite for sand flint in a vitreous body."
8. "Pyrophyllite introduced in vitreous and semivitreous bodies."
9. "Talc as a vitreous body ingredient."
10. "Production of a light green stain for vitreous hotel china."
11. "Bonds for silica brick."
12. "Effect of varying the rate of cooling on the properties of refractories."
13. "Deflocculated clay as a bond for 95% grog brick."
14. "Hardness and abradability of glass."
15. "Study of P_2O_5 in glass."
16. "Durability of glass against acid and alkaline solutions."
17. "Development of orange glass."
18. "Glasses containing lead oxide and titanium."
19. "Study of glassmakers' lime."—M. E. Holmes, *Dean*

OHIO STATE UNIVERSITY

Eight Alumni Placed Since July

W. N. Butterworth, Arthur D. Drake, Paul G. Kates, John L. Lannan, John L. Moser, Joseph W. Moss, H. Zane Schofield, and William F. Yeagley, all former students of the Ceramic Engineering Department, Ohio State University, have accepted new positions.

—Arthur S. Watts, *Chairman of Department*

PENNSYLVANIA STATE COLLEGE

Varied Research Program in Progress

Bennett Ellefson is engaged in a study of the mechanism of adherence of glass to metal. The problem of wetting of the metal surface by the glass is being given particular attention.

Edward C. Henry is working on the plastic flow of clay pastes in relation to the colloidal properties of the respective clays as determined by standard methods.

Paul L. Smith is undertaking a fundamental study of the factors underlying "freezing" of pyrometric cones.

Allen Martin is carrying on an investigation of the mechanism of reactions between solids in absence of a liquid phase.

E. P. McNamara is working on the problem of strength of glass fibers.

Graduates of 1935 Class in Ceramic Industry

Paul McCloskey, Penn State 1935, is with Frigidaire Corporation, Dayton, Ohio, in enameling work.

Donald Wertz, class of 1935, is in charge of development of refractories at the Donora Zinc Works of the American Steel and Wire Company, Donora, Pa.

Student Studies in Orient

Marvin Lewis, class of 1937, is studying at Lingnan University, China, on a scholarship, one of twenty awarded to American and British students. Mr. Lewis will return next year to complete his work in ceramics at Penn State.

—N. W. Taylor, *Head of Department*

UNIVERSITY OF ILLINOIS

Seven Graduates in New Industrial Positions

H. B. Burton, E. F. Creevy, Jr., W. S. Debenham, A. G. R. Lindberg, Perry C. McCollom, H. S. Robertson, and James D. Tetrick have accepted positions in various branches of the ceramic industry recently, see Roster Changes during the past several months.

Howat Establishes Small Pottery

Walter Howat, former student of the department, has established a small pottery of his own in Tottenville, N. Y. His work consists mainly in making sculpture pieces for a number of New York sculptors.

Lyon Completes Work for Doctorate

K. C. Lyon, graduate of the department in 1931, has finished his thesis and passed his final examination for the Doctor's degree. He is employed in the Glass Technology Department, General Electric Company, Cleveland, Ohio.

Coffeen Made Research Assistant

W. W. Coffeen, graduate of 1935, has an appointment as a Research Graduate Assistant. He is working on a problem for the Canton Stamping and Enameling Company, Canton, Ohio, and taking graduate work.

—C. W. Parmelee, *Head of Department*

UNIVERSITY OF NORTH CAROLINA, RALEIGH UNIT

Large Freshman Class Enrolled

The Department of Ceramic Engineering, Raleigh Unit of the University of North Carolina began the year with a freshman registration of twenty-two students, next to the largest in its eleven-year history.

Five students, transfers from other engineering departments and junior colleges, have been added to the sophomore class. Total registration of the department is forty-three.

Four students, working for the Master's degree, are R. L. Stone, former student at the Missouri School of Mines; J. C. Richmond, from Alfred University; and Charles W. Owens, Jr., and R. B. Worth, who were graduated from the University of North Carolina last June.

Research Projects under Way

The olivine research started last year by R. L. Stone will be completed this year. He is also attempting to improve the spalling qualities of magnesite refractories.

J. C. Richmond has undertaken a project involving the use of pyrophyllite in whiteware bodies.

Charles W. Owens, Jr., is attempting to determine whether pyrophyllite can be used to advantage in some types of refractories and in refractory cements. He is also determining the expansion of pyrophyllite when heated to various temperatures and the influence of grain size on expansion.

R. B. Worth is working on the production of a low-cost insulating brick made of shale for house construction.

Former Students in New Positions

E. G. Couch, Jr., A. H. Couch, and H. L. Longenecker have accepted positions in various fields of ceramic research and industry.

Evidence of the improvement in opportunities for ceramic engineering graduates is indicated by the fact that all of the June graduates of the department, who did not return for graduate work, were placed immediately after commencement.

The graduates placed were as follows: J. S. Crawford, H. B. Foster, H. M. Hamburger, E. Jones, Jr., J. U. King, A. S. Lloyd, J. B. Sauls, E. B. Smith, and W. R. McLain.

—A. F. Greaves-Walker, *Head of Department*

Pittsburgh Plate Glass Company Retains Teague

Walter Dorwin Teague, designer and decorator, and his staff have been retained by the Pittsburgh Plate Glass Company.

Mr. Teague's work will include research and design in developing new uses for glass and new designs in glass. In the next few years glass will be more strongly emphasized in building and decoration, it is anticipated.

COMMUNICATIONS—CERAMIC HISTORY

RESEARCH LABORATORY FINISHED IN VITREOUS ENAMEL

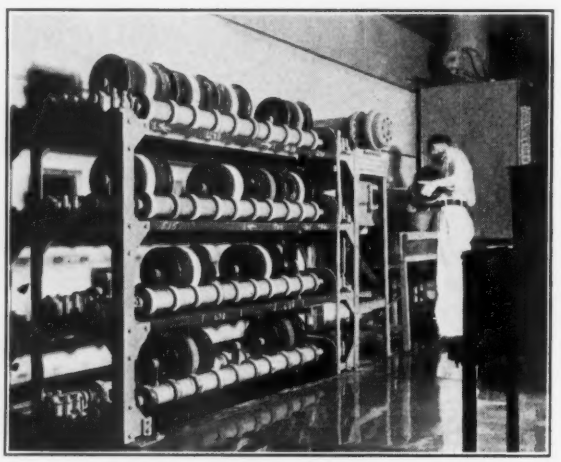
Extensive laboratories have recently been completed by the Chicago Vitreous Enamel Product Company, Cicero, Ill. Nearly 13,000 square feet of porcelain enamel were used in finishing the interior walls, furniture, light fixtures, columns, shower and toilet stalls, and, in two rooms, the ceilings of the laboratories.

A main laboratory room, analytical chemical laboratory, office of the director of research, color- and enamel-control laboratory, physical instrument room, experimental smelting department, smelt record room, and shower and locker room comprise the group.

In the analytical chemical laboratory, a recessed compartment of three divisions contains blast lamps, both electric and gas, hot plates, water baths, and other apparatus used. This compartment is lined with acid-resisting porcelain enamel and the fumes from the operations are carried through a hood and vent of the same material.

This room is completely lined with acid-resisting porcelain enamel. The walls are pastel green and the compartment mentioned above and another for storing chemicals are ivory. The ceiling is finished with ivory-colored porcelain-enameled panels twenty inches square. A 1936 model porcelain-enameled refrigerator is used for cooling solutions.

The five recessed windows have porcelain-enameled ivory reveals. Between the windows, and lining the rest of the room, are panels of pastel green, trimmed with satin-finished, stainless steel strips, all running vertically. This vertical effect is emphasized by the use of lumiline lamps. An ivory-colored, porcelain-enameled panel starts ten feet from the floor and rises three feet to the ceiling. The door to the chemical laboratory is of modern design and has a series of setbacks running vertically, with green faces and ivory reveals, the inside and outside corners of which are trimmed with stainless steel.



Twenty small mills, containing porcelain enamel, may be run simultaneously on this specially-designed mill rack.

The main laboratory room contains 5000 square feet of floor space, and its walls are completely lined with porcelain-enameled panels. The color scheme is reversed ac-

The recently completed office of B. T Sweely, member of the American Ceramic Society since 1916 and one of the foremost research and technical men in the porcelain enamel industry, is shown in this illustration. Walls are finished in egg-plant "velvet mat" porcelain enamel and the ceiling is bright green porcelain enamel with bone-white stripes.

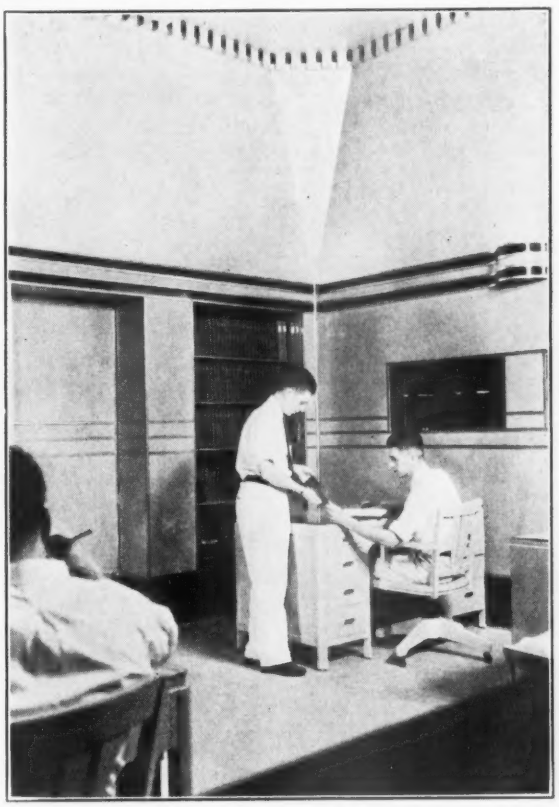
cording to conventional ideas, inasmuch as the panels are light blue at the base and gradually become darker as they near the top, interspersed with continuous strips of satin-finished stainless steel around the room. At the top is an illuminated frieze, three and one-half feet high, starting ten feet from the floor, which demonstrates the effectiveness of porcelain enamel under indirect lighting.

Supporting columns in this room have been transformed into decorative pillars. They have been made into complete lighting fixtures, consisting of seven porcelain-enameled drums, trimmed with stainless steel and blending with the wall colors. These taper from the floor to the ceiling. At the top of the columns appear four large circular and conical porcelain-enameled disks, which distribute light in such a manner that there are no shadows at the column's base. Porcelain-enameled reflectors, which provide an auxiliary lighting system, are recessed into the pink ceiling. Three of these have been made into beam lights by means of parabolic mirrors and spill rings. This throws a concentrated beam over a small area for inspection and other purposes where a strong light is needed.

The color- and enamel-control laboratory is also a headquarters for the engineers employed in the laboratories and provides facilities for filing physical and chemical tests of all raw materials. It is definitely a "daylight room." Porcelain-enameled paneling in a peach color is carried to door height. The top section of walls and ceilings is of masonite covered with aluminum leaf. This acts as a light reflector and conserves all daylight coming into the room. A plum-colored trim and stainless steel strips have been used to relieve the peach walls. The furniture and floor are pearl gray. Artificial lighting in the room is indirect and the source is concealed.

In contrast to the daylight room is a "dark room," in which the color scheme and lighting effects have been carefully designed. Walls of the room, which is thirty-four feet long and eighteen feet wide, are finished in burgundy-red enameled panels, which also have a gloss finish visible between a diamond pattern. This has been stenciled to give an etched or sandblasted effect. Recesses, which have been designed for shelves upon which to place various pieces of delicate equipment, are in a deep blue porcelain enamel. The ceiling, furniture, and Venetian blinds have been painted the same color. The only general lighting in the room emanates from a porcelain-enameled trough in the ceiling, extending the length of the room. This provides a dim streak of light. Other light in the room is used in connection with the instruments, such as photomicrographic camera, interferometer, reflectometer, spectrophotometer, and densitometer.

The laboratories are completely air-conditioned through the use of water from the Company's wells. The filtering of air prevents any foreign materials from coming into the rooms.



A corner of the color- and frit-control laboratory is shown here. The aluminum leaf ceiling and peach-colored porcelain-enameled walls make this "daylight room" an ideal place for visual inspection work.

Considerable thought was given to the design of the shower and locker room. This contains lockers for the laboratory personnel, two toilet stalls, two lavatories, and a shower stall. A feature of the latter is a nonskid floor of porcelain enamel. Extending around the room and in front of the stalls, is a porcelain-enameled mural of marine design, resembling an aquarium. The ceiling and upper walls are in black porcelain enamel, with horizontal stainless steel strips.

B. T. Sweely, one of the foremost research and technical men in the porcelain enameling industry, is the Director of Research for this Company. In his office, the important and intricate work of the laboratories is directed and coordinated. Mr. Sweely's office has been designed to be a room with no sharp angles. It is rounded off into large radius corners, introducing curves all running in parallel planes. The walls are egg-plant "velvet-mat" porcelain enamel, and the ceiling is a bright green with two bone-white stripes. The floor is in egg-plant linoleum, with a circular bone-white strip following the contour of the room. The modern furniture is bone white with the desk and table tops in green porcelain enamel. An unusual filing cabinet has bone-white woodwork with a green porcelain enameled top. All upholstering is green and white pigskin fabrikoid. In a recessed compartment of the room is a complete library on ceramics and related subjects.

One of the outstanding features of the laboratories and a contribution to the art works relating to porcelain enamel is a striking oil painting showing a worker "tapping off" a smelt of porcelain-enamel frit. This occupies a large space recessed in one of the walls of Mr. Sweely's office. It was done by Herbert H. Field, Jr., a prominent painter of industrial subjects.—GEORGE P. MACKNIGHT

CHINA'S NATIONAL BUREAU OF INDUSTRIAL RESEARCH

This Bureau was established under the Ministry of Industry for the purpose of undertaking research and experiment on the better utilization of raw materials, improvement of industrial technique, and betterment of industrial production as a whole.

In pursuance of these duties and objects, several laboratories have been set up to undertake their respective research work along the different lines of industry.

The ceramic laboratory has the responsibility of improving the Chinese ceramic manufacture. Due to effort of many years, this industry in some respects is greatly improved under its technical direction. Improvement, however, should not be confined wholly to the technique of the present time. Greater success, it is believed, may be achieved by making close contact and by coöperating with other industrial organizations, especially with the American Ceramic Society, which has contributed greatly to the ceramic industry.—YU-TSUAN KU, *Director*
NANKING, CHINA

38th ANNUAL MEETING

American Ceramic Society

Columbus, Ohio—March 29 to April 4, 1936

DESHLER-WALLICK HOTEL AND NEIL HOUSE

Three months remain in which to prepare programs. Some of the Divisions have their programs outlined and partially filled.

It is incumbent upon each member of the Society to make known the title of paper or papers he will contribute. It is a retarding of progress to await promptings of committees.

Please be self-prompting; this you do in behalf of your own interests, for the largest benefits accrue to those who contribute most to these Meeting programs.

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VOLUME 14, 1935

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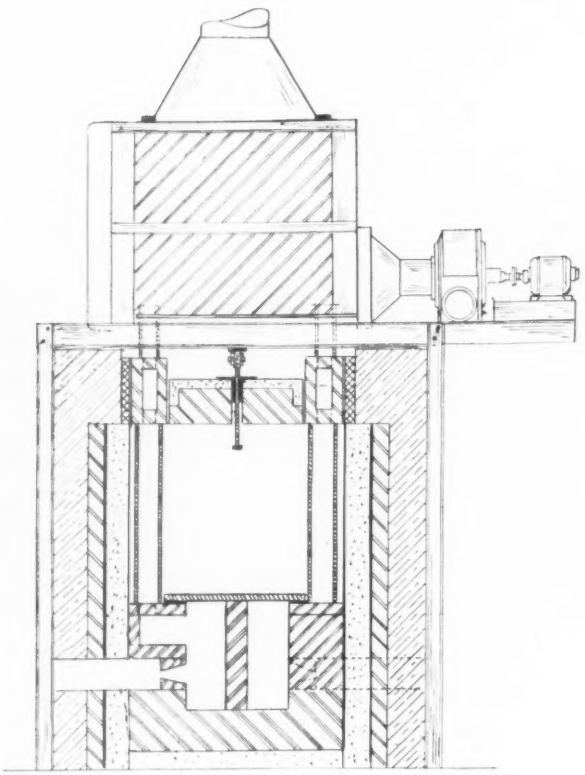

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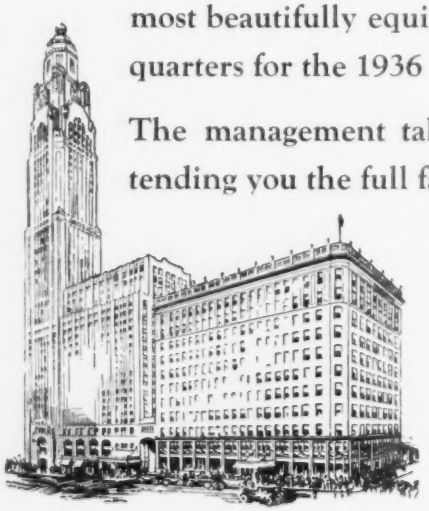

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The Hommel Co., O., Inc.
Norton Co.
The Vitro Mfg. Co.

Alundum (Refractory Products)
Norton Co.

Ammonium Bicarbonate
Solvay Sales Corp.

Ammonium Bifluoride
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Ammonium Carbonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.

Antimony Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Arches (Interlocking, Suspending, and Circular)
Simplex Eng. Co.

Ball Mills
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
McDanel Refractory Porcelain Co.
The Vitro Mfg. Co.

Ball Mills (Laboratory Type)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Barium Carbonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Batch Systems
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Batts
Carborundum Co. (*"Carbofrax Aloxite"*)
Denver Fire Clay Co.
Norton Co. (*Alundum Crystolon*)

Bitstone
Consolidated Feldspar Corp.
Potters Supply Co.

Blocks (Refractory)
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
The Vitro Mfg. Co.

Borax
American Potash & Chemical Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Borax Glass
American Potash and Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Boric Acid (Anhydrous)
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Vitro Mfg. Co.

Boric Acid (Crystal, Granular, or Powder)
American Potash & Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Boron Carbide
Norton Co.

Brick (Refractory)
Carborundum Co. (*"Carbofrax Aloxite"*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
The Vitro Mfg. Co.

Carbofrax (Refractory Products)
Carborundum Co.
Chicago Vitreous Enamel Product Co.

Carbolon (Refractory Products)
The Exolon Co.

Carbonates (Barium, Lead)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Castings (Abrasive Resisting)
Bethlehem Steel Corp.

Castings for Molds and Plungers
Simpson Foundry & Eng. Co.

Caustic Potash
Solvay Sales Corp.

Caustic Soda
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Cements
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Norton Co.
Pittsburgh Plate Glass Co.

Ceramic Chemicals
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Chromium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay (Ball)
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Potters Supply Co.
The Roessler & Hasslacher Chemical Co.
Spinks Clay Co., H. C.
The Vitro Mfg. Co.

Clay (China)
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay (Electrical, Porcelain)
Ceramic Color & Chemical Mfg. Co.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
Kentucky-Tennessee Clay Co.
Spinks Clay Co., H. C.

Clay (Enamel)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Ferro Enamel Corp.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Metal & Thermit Corp.
Paper Makers Importing Co.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Spinks Clay Co., H. C.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Clay (Fire)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Clay (German Vallendar)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay Miners
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clay (Potters)
Denver Fire Clay Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clay (Process Equipment)
Bonnot Co.

Clay (Sagger)
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.
Spinks Clay Co., H. C.

Clay (Wad)
Kentucky-Tennessee Clay Co.
Potters Supply Co.
Spinks Clay Co., H. C.

Clay (Wall Tile)
Hammill & Gillespie, Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clocks (Gauge Board)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.

Cobalt Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Colors
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Cones
The Edward Orton, Jr., Ceramic Foundation

Conveying Equipment
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Cornwall Stone (Imported)
Consolidated Feldspar Corp.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Crucibles (Filter, Melting, Ignition)
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Crystolon (Refractory Products)
Norton Co.

Cullet, Washing Plants, Incinerators, Crushers
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Decorating Supplies
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Drying Machinery
Ferro Enamel Corp.

Enameling Equipment (Complete)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Enameling Furnaces
Carborundum Co. (*Carboradiant*)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Norton Co.
Porcelain Enamel & Mfg. Co

Enameling Iron (Sheet)
American Rolling Mill Co.

Enameling Muffles
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Norton Co. (*Alundum*)
Pittsburgh Plate Glass Co.

Enameling (Practical Service)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Enamels (Porcelain)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Equipment (Porcelain Enameling)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Exolon (Refractory Products)
Ferro Enamel Corp.
The Exolon Co.

Feldspar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Finishing Tools
Simpson Foundry & Eng. Co.

Fire Brick
Carborundum Co.
Denver Fire Clay Co.
Ferro Enamel Corp.
Norton Co.

Fire-Polishing Machines
Simpson Foundry & Eng. Co.

Flint
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Flint Pebbles
Chicago Vitreous Enamel Product Co.
Consolidated Feldspar Corp.
Ferro Enamel Corp.
The Hommel Co., O., Inc.

Floors (Non-Slip)
Norton Co.

French Flint
Consolidated Feldspar Corp.
Paper Makers Importing Co.

Frit
Allied Engineering Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Fuel Oil Systems and Control, Stokers
Simplex Eng. Co.

Furnaces
Allied Engineering Co.
Carborundum Co. (*Carboradiant*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Glass Bending Ovens, Glass Decorating Machines
Simplex Eng. Co.

Glass Equipment
Hartford-Empire Co.
Simpson Foundry & Eng. Co.

Glass Melting Tanks and Furnaces
Simplex Eng. Co.

Glass Thickness Gauge
Bausch & Lomb Optical Co.

Glaze and Body Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Glazes and Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Glaze Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Goggles
Willson Products, Inc.

Gold
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Grinding Mills
Simpson Foundry & Eng. Co.

Grinding Wheels
Norton Co. (*Alundum Crystolon*)

Hearths
Carborundum Co.
(*Carbofrax* heat treating)
Norton Co. (*Crystolon*)

Hearths (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
Norton Co.

Iron (Enameling)
American Rolling Mill Co.

Iron Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Kaolin
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.

Kettles of All Kinds
Simpson Foundry & Eng. Co.

Kilns, China (Decorating)
Allied Engineering Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.

Kryolith
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Ladles (Cast-iron)
Simpson Foundry & Eng. Co.

Leeds (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.

Lehrs
Simpson Foundry & Eng. Co.

Lehrs (Electric or Fuel Heated)
Simplex Eng. Co.

Lehr Loaders
Simpson Foundry & Eng. Co.

Linings (Furnace Refractory, Block Refractory Plate, Brick and Tile)
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
The Vitro Mfg. Co.

Magnesia (Sintered, Calcined)
Drakenfeld & Co., B. F.
The Exolon Co.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Norton Co.

Magnesite
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.

Manganese
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Manganese (Oxide)
The Roessler & Hasslacher Chemical Co.

Masks (Breathing)
Willson Products, Inc.

Metals (Porcelain Enameling)
American Rolling Mill Co.

Microscopes (Polarizing)
Bausch & Lomb Optical Co.

Minerals
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Muffles (Furnace)
Allied Engineering Co.
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Ferro Enamel Corp.
Norton Co.
Pittsburgh Plate Glass Co.

Mullite (Artificial)
The Exolon Co.

Muriatic Acid
Denver Fire Clay Co.
The Hommel Co., O., Inc.

Nitrates (Cobalt, Sodium)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Norbide (Norton Boron Carbide)
Norton Co.

Olivine
The Roessler & Hasslacher Chemical Co.

Opacifiers
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Oxides
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Pins
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Potters Supply Co.

Polariscope
Bausch & Lomb Optical Co.
Simpson Foundry & Eng. Co.

Porcelain Enameling Service (Practical)
American Rolling Mill Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Porcelain Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Potash (Carbonate)
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Pot-setting Tools
Simpson Foundry & Eng. Co.

Presses, Side-lever and Bench
Simpson Foundry & Eng. Co.

Producer Glass Plants
Simplex Eng. Co.

Pyrometer Tubes (Refractory and Hard Porcelain)
Denver Fire Clay Co.
McDanel Refractory Porcelain Co.
Norton Co.

Pyrometric Cones
The Edward Orton, Jr., Ceramic Foundation

Raw Material Handling Equipment
Simpson Foundry & Eng. Co.

Refractometers
Bausch & Lomb Optical Co.

Refractories
Carborundum Co.
Denver Fire Clay Co.
The Exolon Co.
Norton Co.
Pittsburgh Plate Glass Co.

Refractory Materials
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
The Exolon Co.
Kentucky-Tennessee Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Titanium Alloy Mfg. Co.

Respirators
Willson Products, Inc.

Rutile
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Saggers
Carborundum Co.
Norton Co.
Potters Supply Co.

Salt Cake
American Potash & Chemical Co.

Saponin
Jungmann & Co., Inc.

Selenite of Sodium
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Selenium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sheets (Enameling Iron)
American Rolling Mill Co.

Silica (Fused)
The Exolon Co.
The Hommel Co., O., Inc.

Silicate of Soda
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Philadelphia Quartz Co.

Silicon Carbide
Carborundum Co.
The Exolon Co.
Norton Co.

Silicon Carbide Firesand
Carborundum Co.
The Exolon Co.

Sillimanite (Synthetic)
The Exolon Co.
Pittsburgh Plate Glass Co.

Slabs (Furnace)
Carborundum Co.
Norton Co.

Smelters
Ferro Enamel Corp.
Porcelain Enamel & Mfg. Co.

Soda Ash
American Potash and Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Sodium Antimonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sodium Fluoride
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sodium Silica Fluoride
Jungmann & Co.

Soot Blowers
Simpson Foundry & Eng. Co.

Special Machines
Simpson Foundry & Eng. Co.

Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Spurs
Potters Supply Co.

Stilts
Potters Supply Co.

Sulfuric Acid
Denver Fire Clay Co.
The Hommel Co., O., Inc.

Talc
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Tanks (Pickle)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.

Tanks for Raw Material Steel or Concrete
Simpson Foundry & Eng. Co.

Tile (Floor)
Norton Co.

Tile (Muffle)
Norton Co.

Tile (Refractory)
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.

Tile (Wall)
Denver Fire Clay Co.
Ferro Enamel Corp.

Tin Oxide
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Titanium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Titanium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Tubes (Insulating)
McDanel Refractory Porcelain Co.
Norton Co.

Tubes (Pyrometer)
Denver Fire Clay Co.
McDanel Refractory Porcelain Co.
Norton Co.
Pittsburgh Plate Glass Co.

Valves (Butterfly and Reversing)
Simpson Foundry & Eng. Co.

Water Softening Plants
Simplex Eng. Co.

Wet Enamel
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Whiting
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Zinc Oxide
Jungmann & Co., Inc.

Zirconia
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Titanium Alloy Mfg. Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

WILLSON BAG RESPIRATORS

Nos. 300 and 400 (Patent applied for) have

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A Willson style for every dusty operation in the Ceramic Industry.

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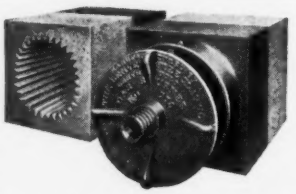

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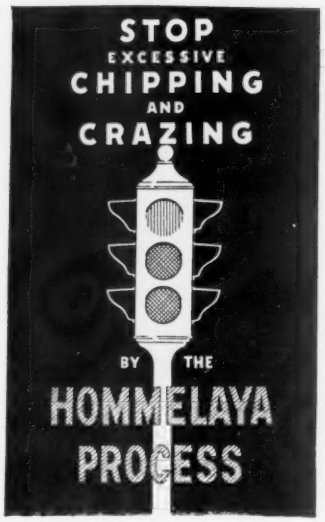

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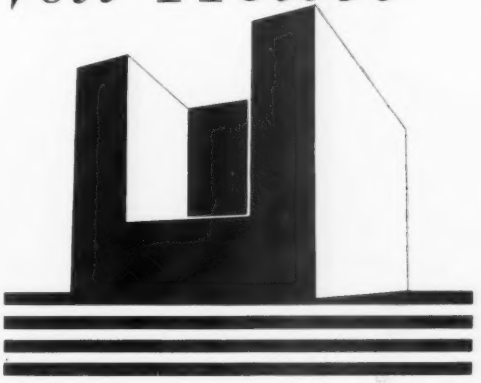

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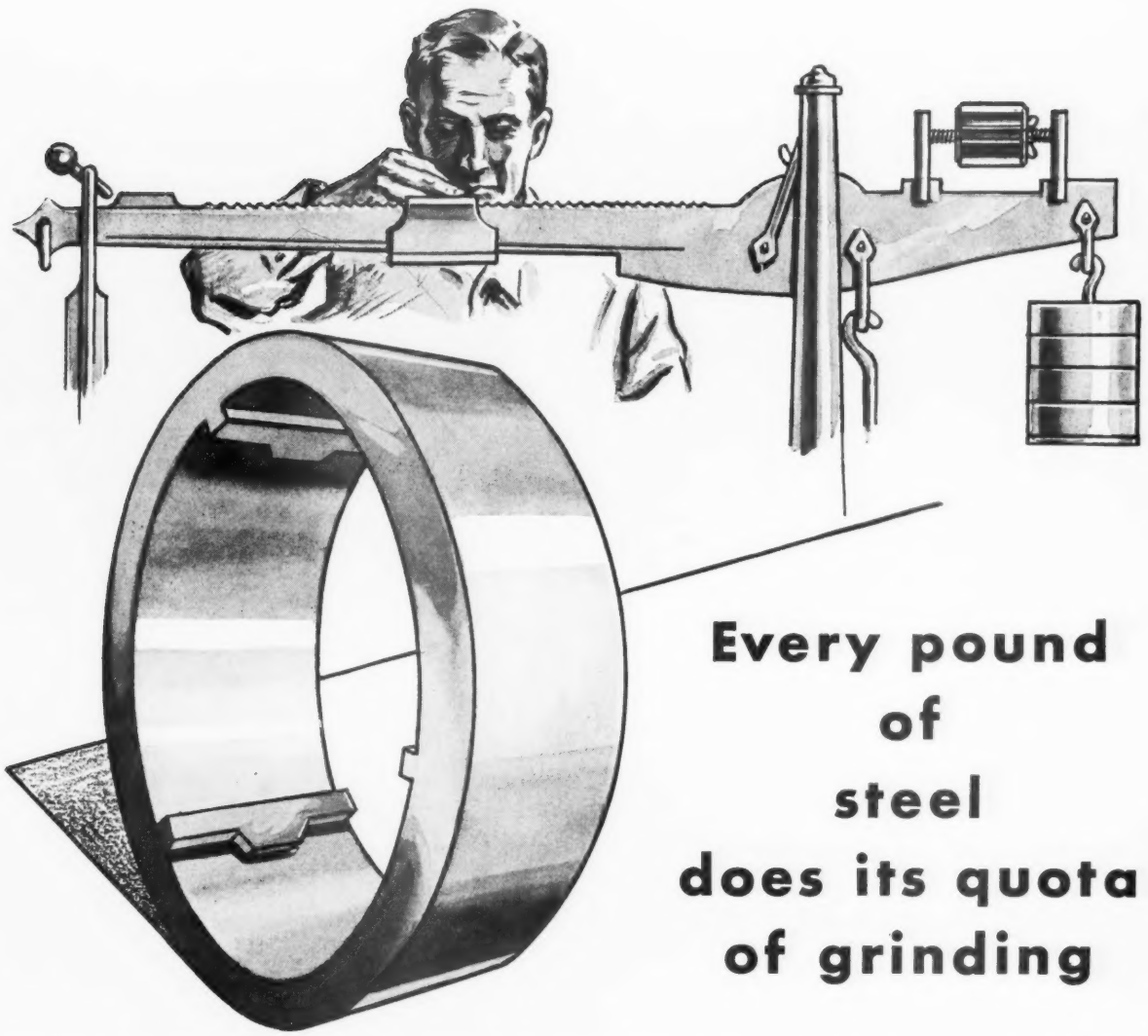

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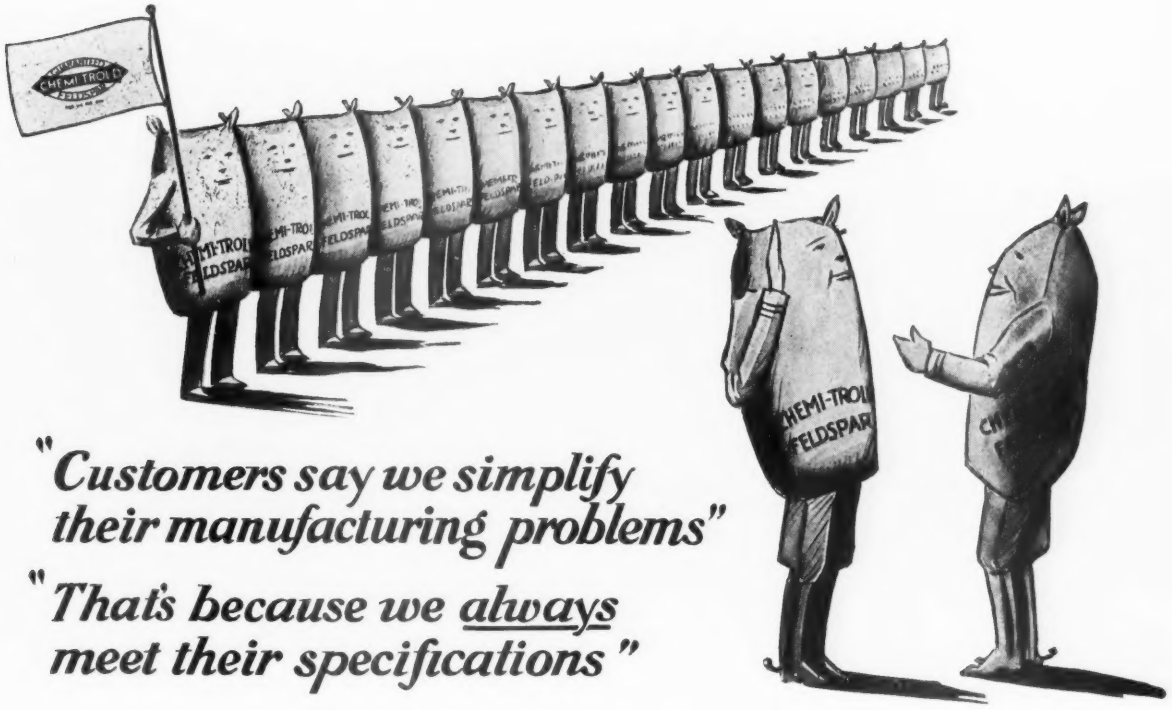

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Dec. 1, 1935

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Pete, we feel that our big sheds full of CHAMPION, CHALLENGER and JERNIGAN BALL—PARIS TOP WHITE—JERNIGAN and GLEASON SAGGER—BLACK and TAN WAD are a Christmas present to all of us. A sort of horn of plenty that will supply us all winter long with good dry clay.

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From

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Vol. 14, No. 12, pp. 383-416 (1935)

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